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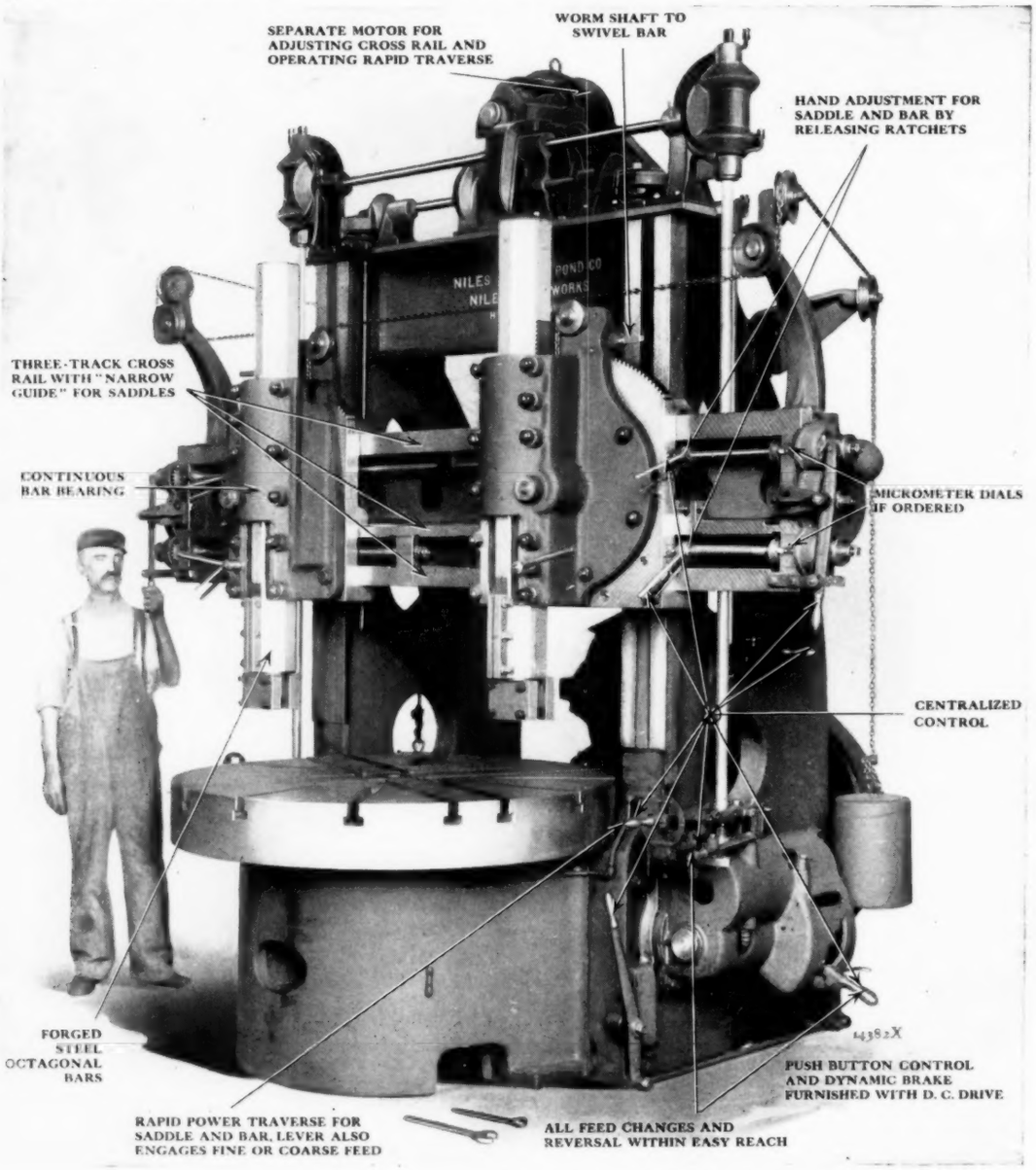
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Building Curtiss Aeroplane Motors

By Fred H. Colvin

SYNOPSIS—A sudden and insistent demand for a product often brings out latent possibilities which the shop itself did not realize it possessed. Although the Herschell-Spillman Co. has been working into the building of automobile motors for several years, the requirements of the large Curtiss aëroplane motors brought forth many interesting tools and methods, most of which can be applied to other work.

The power required to drive aëroplanes at high speed has for several years made the eight-cylinder motor the standard in the Curtiss machines. These motors, however, until the building of the large flying boat "America," usually ranged in the 100-hp. class, or below. For this machine, with its large boat body and its 72-ft. spread of wings, two motors of 160 hp. each were designed and built. And it is motors similar to these, with 5x7-in. cylinders, that are now being used on many of the large machines.

One of the first operations on the engine base is shown in Fig. 1, which illustrates one of the fixtures designed for the first lot of motors, which, though exceedingly simple, have proved very satisfactory. These fixtures are simply V-blocks of large size for holding the base while the the crankcase surface is being milled on a Brown & Sharpe vertical machine. This is done with a large inserted tooth mill built especially for this work in their own toolroom. It is run at something over 150-ft. cutting speed per minute.

The crankcase is then bored for the crankshaft bearings on the Lucas horizontal boring machine, shown in Fig. 2. In this operation the base is held in a suitable fixture, which locates the boring bar in the different positions, the crankshaft bearing forming the base line from which the cylinder fitting surfaces are milled.

Milling Fixture for 90-Deg. Surfaces

The special fixture for this is shown in Fig. 3, in which the mandrel *A* is clamped in the crankshaft bearing and fits in the three uprights and in the cross-member of the fixture at the right. Another mandrel, *B*, fits into the

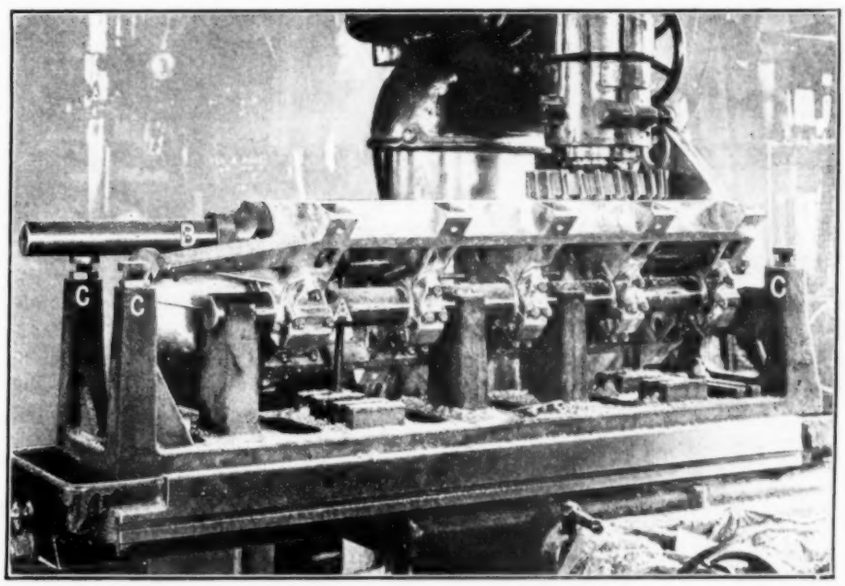


FIG. 3. MILLING FIXTURE FOR 8-CYLINDER CRANKCASES

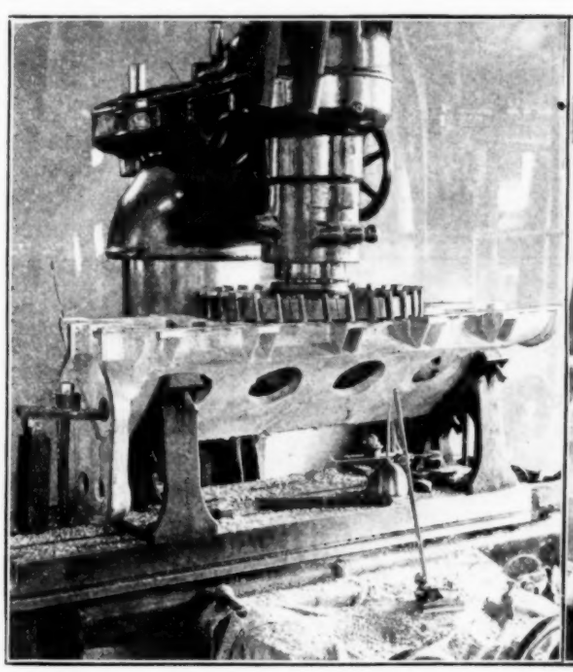


FIG. 1. SIMPLE FIXTURE FOR CRANKCASE MILLING WITH INSERTED CUTTER

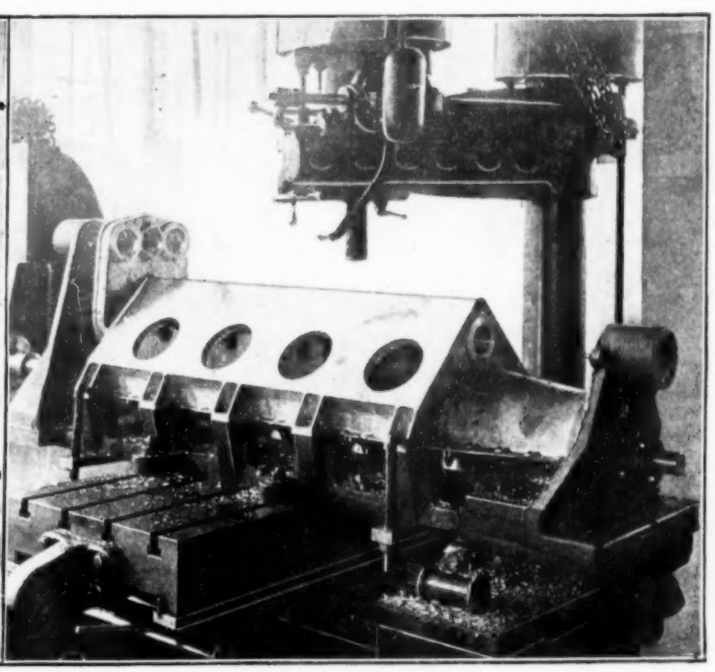


FIG. 2. BORING CRANKSHAFT AND CAMSHAFT BEARINGS IN SPECIAL FIXTURE

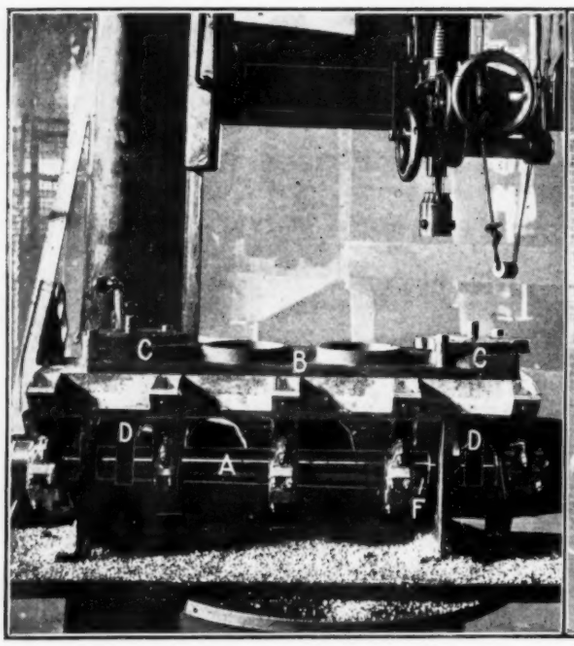


FIG. 4. FIXTURE FOR BORING OFFSET 8-CYLINDER CRANKCASES

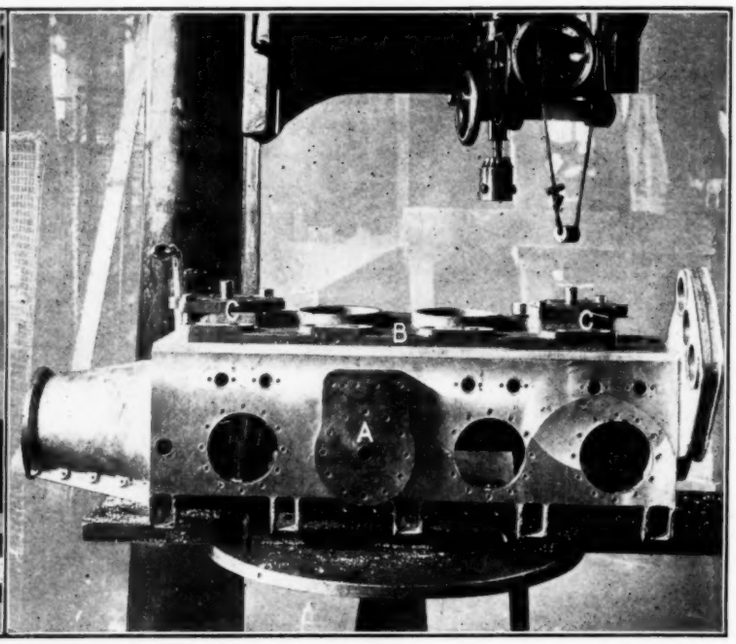


FIG. 5. DRILLING JIGS FOR OFFSET CYLINDER BOLT HOLES

camshaft hole and acts as a locating point for holding the surface to which the cylinders bolt at their proper angles. This is accomplished by means of the adjustable stops *CCC*, which locate the surfaces being milled so as to insure their being exactly 90 deg. from one another. This is the desired angle to give the proper rod connections. The fixture is very rigid and has been accurately made to handle this work rapidly and with the needed precision.

Dispensing with Knuckle Joints

The motors have offset cylinders, so that the connecting rods couple side by side to the same crank pin instead of using the knuckle joints, as in some of the automobile-motor designs. This offset is secured by clamping the mandrel *A*, Fig. 4, in the crankshaft bearing, the mandrel having two grooves at the proper distance apart to represent the offset of the cylinders. With this mandrel in position the plate *D* is laid on the cylinder receiving surface and is positioned by the pieces *CC*, which fit into the end openings of the fixture *B* and carry the projecting fork *BB* into the grooves previously mentioned.

This locates the plate *B* in its correct position, and the holes which locate the cylinders correctly are then bored with a special cutter. After these holes are bored the plate is shifted 90 deg. to the other cylinder surface and the cylinder holes are properly located by placing the forks *DD* in the other grooves.

This can be seen more clearly in Fig. 5, which also shows the way in which the cylinder bolt holes are drilled. The drilling jig *A* is located from the two valve-rod pusher holes by means of dowels, not shown, these holes being bored in the same fixture that locates the cylinder holes previously mentioned. This also shows the plate *D* and the locating plugs *CC*.

Machining the Manifolds

Another interesting job which has been accomplished with comparatively simple fixtures is the machining of the intake manifolds, the first operation being shown in Fig. 6. These are mounted on a special plate, the manifold being held in the form shown, simple clamping devices holding it in position during the machining operations. This plate, which also carries a counterbalanc-

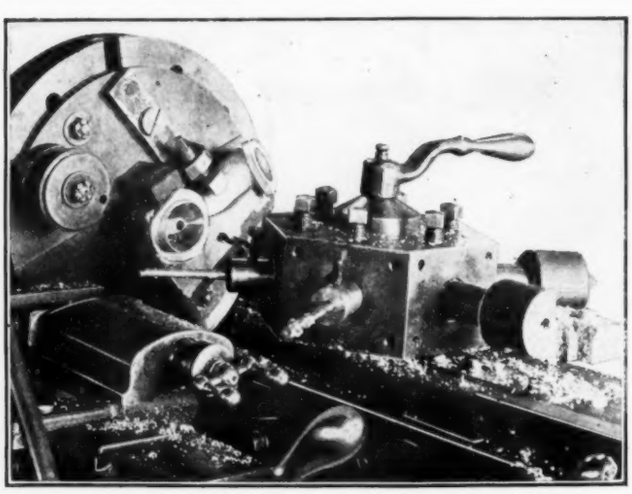


FIG. 6. MACHINING INTAKE MANIFOLDS

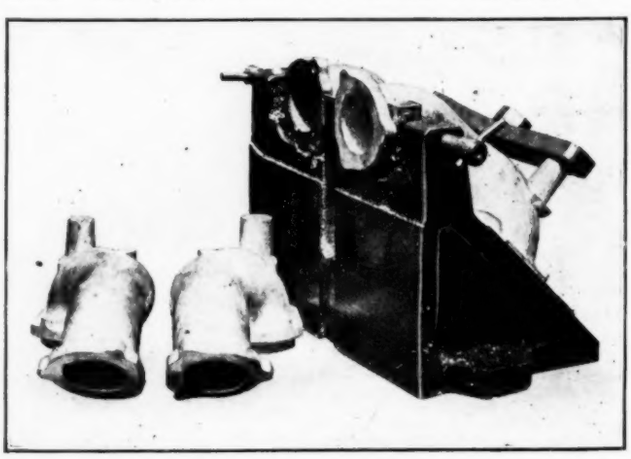


FIG. 9. MILLING FIXTURE FOR INTAKE MANIFOLDS

ing weight, is bolted to the regular faceplate, as can be seen.

Figs. 7, 8 and 9 show the drilling of this manifold, the first two giving two positions of the indexing trunnioned jigs. These need practically no explanation, except possibly for the milling fixture in Fig. 9. In each case these fixtures handle a pair of manifolds, one right-hand and one left-hand, for milling the flat surface for the connecting gasket.

One of these manifolds is shown after being drilled to show how the milling cutter surfaces them to the desired thickness.

The crankcase of the Curtiss motor is very deep and contains a large oil sump so as to insure constant and positive lubrication of the motor regardless of the angle at which the machine is flying. Two of these crankcases are shown in Fig. 10, the one at the left being turned in a reverse position in order to show the surfaces which are faced by the milling fixture shown at the right. This fixture consists of the plate *A*, which is located by the pins *BB* and clamped by the bolts *CC* in the proper position for milling the surface *E* to accommodate the pipe fitting shown. The milling fixture has been moved back in order to show the milling cutter *E*, which is swung around the center *F* by means of the lever *G*. The milling cutter is driven by the flexible shaft *H*. The ledge inside the crankcase carries an aluminum pan with a hump in the center to clear the central spiral gear *I* which drives the two vertical shafts shown. The central gear *I* is driven from the motor crankshaft through the gear shown, this being the special lubricating pump which has been designed particularly for this class of work. Some of the machining operations on the pump are shown in Figs. 3 and 4; but its operation is of sufficient interest to warrant a brief description.

Fig. 11 shows a pair of forming dies for the aluminum plate seen in the center. This plate is about $\frac{1}{16}$ in. thick, yet it is easily formed by the dies shown, which are of pine planks, and are forced together by an arbor press in lieu of more suitable machinery being available. This forms the usual oil trough of the engine, leaving the large sump beneath. The holes in this are drilled by the bronze jig shown beside this plate, steel bushings being used in each hole. Bronze was chosen for this on account of the light section and because it was feared that cast iron would break with a sudden jar. The jig at the extreme left is used in the crank case for the holes, which match those of the aluminum separation plate shown.

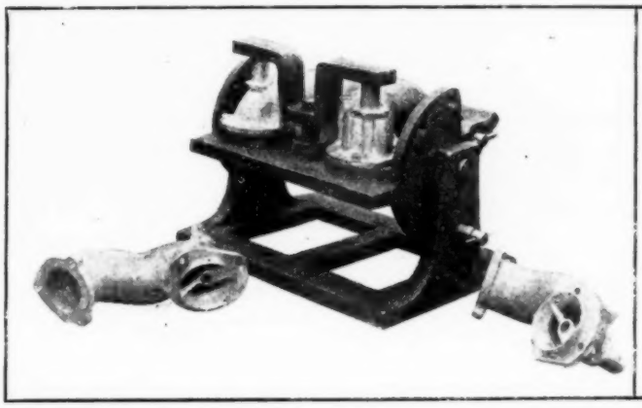


FIG. 7. DRILLING JIG FOR INTAKE MANIFOLDS

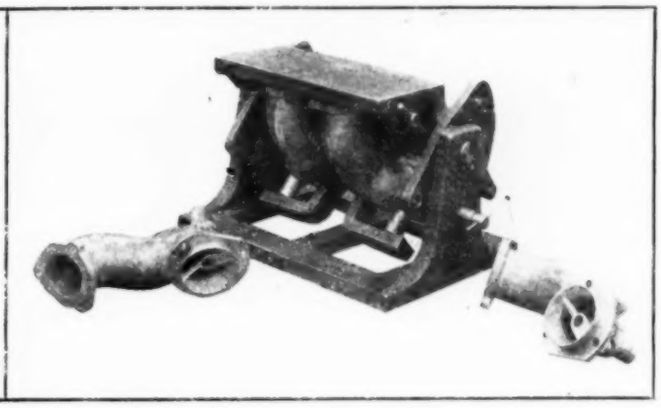


FIG. 8. ANOTHER POSITION OF THE SAME JIG

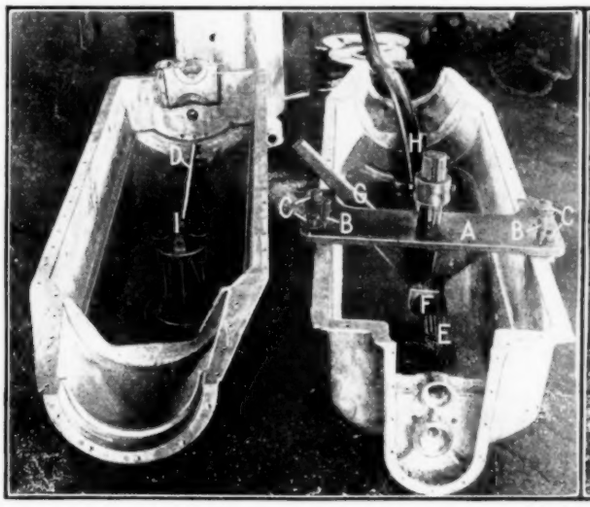


FIG. 10. MILLING FIXTURE FOR INSIDE BOSSES

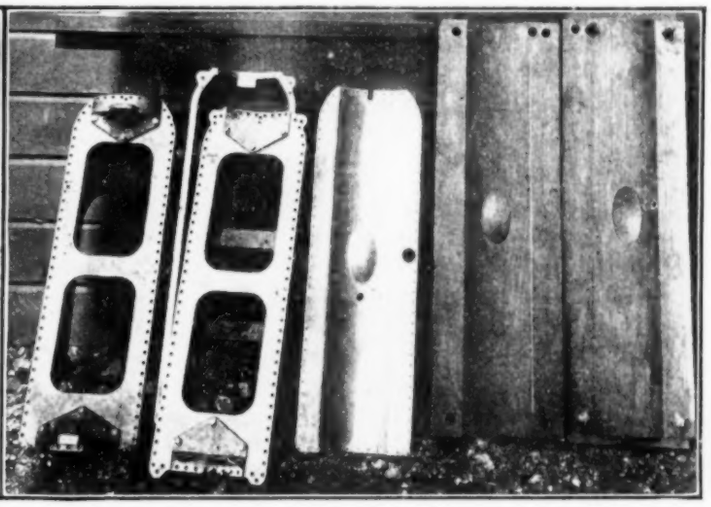


FIG. 11. FORMING DIES AND DRILL JIG FOR CRANK-CASE PARTITION

The Largest Commercial Petrol Engine is thought to have been built for installation in a double-ended ferry boat used for the transportation of trains across an arm of San Francisco Bay. This engine weighs nearly 50 tons and develops 600 hp. It has four cylinders of 16 in. bore. The normal speed is 225 r.p.m. The trips are not long, and between runs all fuel consumption ceases, effecting a considerable saving over steam despite the high cost of fuel for operating an engine of this size.

Machine-Shop Memories--Circumstantial Evidence

By T. E. White

I was once in a shop that had some strict rules against fighting. The foreman was a big, quiet man and awfully strict, although I must say he was a just man. One of the men there was named Fritz. Fritz was big and he had the impression that if he ever died or quit, they would have to get the best man in the world and redesign him to bring him up to the requirements, and then maybe the shop would be able to stagger along for a year or two. Fritz and the superintendent came from the same town in the old country, and he was supposed to have a pull. As to that, I never found out whether he did or not, but I know he had no pull with me.

Butting in on the Job

I had worked about an hour one day, chucking a job in a lathe, and had gotten it just right. In going to the bench for my calipers, I turned my back to the lathe for possibly five minutes. In the meantime Mr. Fritz came along with a piece of shafting in one hand a scraper in the other and laid the shaft on the shears of the lathe I was working on and proceeded to calmly loosen up the chuck jaws. I turned around just in time to see my job fall into the chip box.

I had left a tool in the tool post to hold the lathe, that being the shop rule, so I walked quickly over to the lathe and asked Fritz why he took my job out when he saw a tool in the tool post. His answer was not calculated to cool my rising wrath. He said he took the job out because he wanted to and asked me, "Vat you going to do about it?" I bounced around the end of that lathe and proceeded to demonstrate to him.

Circumstantial Evidence Convicted Fritz

In going around the lathe I took hold of the tailstock to assist myself and in some way cut my wrist to the bone, I never found out what did it and in fact I was so mad I didn't notice it then, but I knocked Mr. Fritz head-over-heels over a pile of castings. He jumped up and came at me with the scraper, just as the foreman grabbed him. I thought I was fired sure, but by luck I got out of it. The foreman held an inquiry right there, and I told him what Fritz had done and said that when I protested to him in a mild way he had stabbed me with the scraper, and showed my wrist to prove it!

There was a man near-by who said he saw Fritz do it and another who was willing to swear that Fritz had made threats against me several times in his presence. That settled Fritz. He was so angry he couldn't make himself understood, and the foreman told me to go back to my work, and he had Fritz transferred to another department.

Put the Back Gears on Your Temper

I have had a lot of scraps in my life and every one of them could have been avoided if I had used a little common sense and had put the back gears on my tongue and temper. I'm nearly 40 now and I don't do those things any more, because I never got anything out of those escapades except a little fun and excitement. I never remember being called up to the main office after one of my scraps and, while getting my pay raised, told that I would have to take charge of the shop because I was such a good fighter I would make a good boss.

No, boys, it don't pay to be a scrapper.

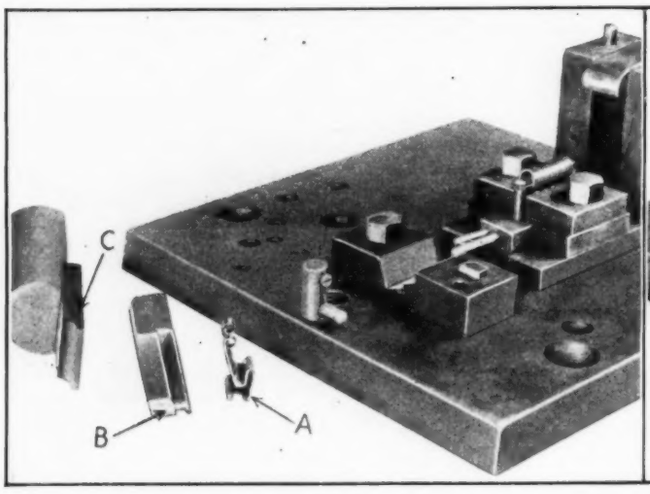


FIG. 1. BRUSH-HOLDER FORMING PUNCH AND DIE

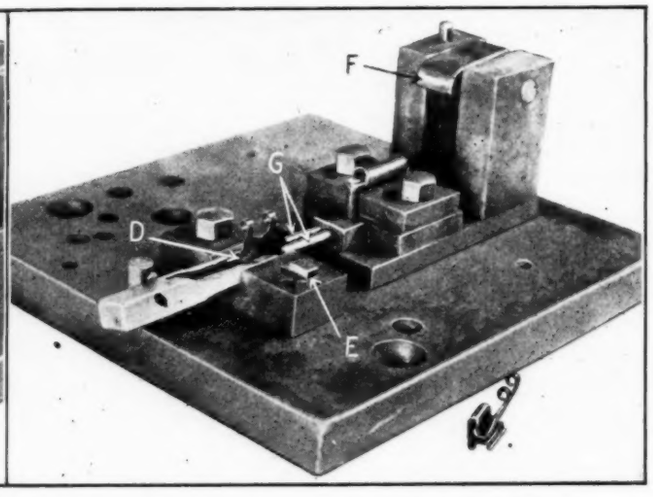


FIG. 2. THE FORMER AND WORK IN PLACE

Forming a Brush-Holder

A piece of peculiar shape is made by the Keyless Lock Co., Indianapolis, Ind. It is a brush-holder for an automobile self-starter. The piece in its final form is shown at *A*, Fig. 1. First, it is bent into a channel form with one arm longer than the other and the forked ends curled as shown. Next the channeled piece is slipped over the former *B*, which is then laid in the die at the right. The extra bend is made by bringing down the punch *C*, which forces the metal into the groove of the former.

The former and bent piece are shown in position in Fig. 2. The way the punch forces the metal down into the groove is shown at *D*. The plug *E* is used as a locating piece, which the forks of the brush-holder straddle as the channeled piece is laid in the die for the final bend. When the press ram rises, a hook catches the end of the swinging dog *F* and causes the knockouts *G* to move outward and force the former and work out of the die.

Maintenance of Small-Shop Belts

By John H. Van Deventer

SYNOPSIS—Next in importance to the correct selection of a belt is its proper maintenance. The tension to which it is stretched is an item that has a great effect on driving power and on the total length of service that may be expected. Idler pulleys and the advantages to be had from their use are discussed and a number of practical points relating to the care of belts are given.

A man returned from the South recently and related a yarn which while it punctures the boundaries of truth in a few places is worth passing along. Hank Perkins, a New England mechanic, moved down to the Louisiana sugar country and started up a machine shop. This does not mean that he commenced operations in a new shop, for what Hank did was to start an old one going again that had been standing idle for a number of years. One of his first acts was to speed the main-line shaft up from its former rate of 75 revolutions a minute to something near 250 turns, which necessitated equipping it from one end to the other with new drive pulleys.

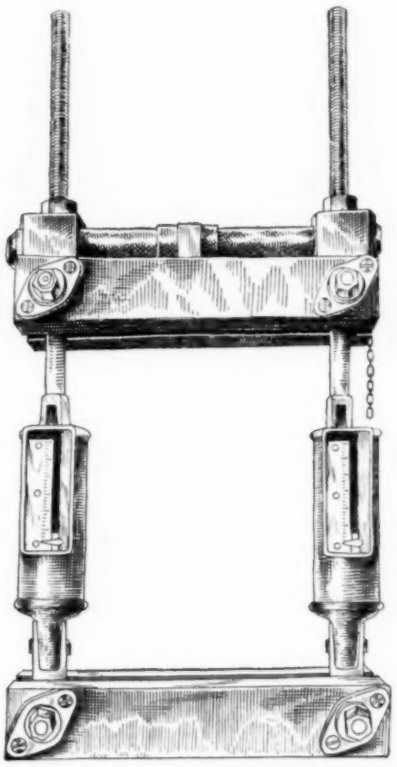


FIG. 1. TENSION SCALES

Hank found that sulphur was running pretty high in the neighboring foundries, and that the best pulleys he could get had their faces plentifully besprinkled with blow-holes. As long as a group of these did not go clean across the face of the pulley and cut it in two, he considered it policy as a stranger to say nothing and make the best of it.

Hank hired a husky, flat-footed, chocolate-visaged coon who applied for the job of engineer and millwright, and who said he had held down this combination when "Massa Brown" ran the shop. Great was Hank's surprise one day about noon to spy the dusky millwright pouring molasses out of a stone jug upon the overhead belts.

"Sambo," exclaimed Hank, "what are you putting that dog-gone stuff on the belts for?"

"Why, Massa Hanks, that's sure nuff de mos' pow'ful belt dressin' ever was. You wait 'til after dinnah, boss, and see foh yo'self."

At dinner time Hank saw about 10,000 flies light upon the belt in anticipation of a feast and end up by sticking fast to it. When the darky blew the whistle and started up the engine he saw the possibilities of molasses as a belt dressing, for the flies which stuck fast to the belt fitted into the blow-holes on the pulleys and made the belt pull like the dickens—sort of a chain-drive! There were plenty of flies available, plenty of molasses and plenty of blow-holes; so, with these three sources of supply, Hank saw that he would have no trouble with his belts.

Starting with the Belt at the Proper Tension

Most small-shop owners are not as fortunate as Hank was in having a simple remedy for belts which will not pull; for even belts which are properly selected for their work get lazy and stretch and lay down on the job. The great problem in the shop is to keep belts in an average

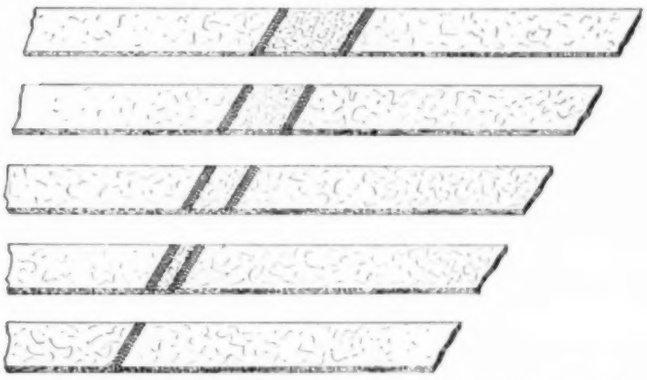


FIG. 2. STRETCHING A NEW BELT WITH TAKE-UP PIECES OF VARIOUS LENGTHS

condition of tightness which will make them deliver a maximum of pull divided by a minimum of trouble, and to accomplish this is worth some study and effort on the part of the shop owner.

There is as much harm done in getting a belt too tight as not tight enough, for this results in wear and tear on the countershaft and line shaft bearings and, what is even worse, wear and tear on the belts themselves. When you have too much tension there is also an unusual stretch, and before you know it the belt is literally "down and out."

It does not cost much to know what tension a belt is under when it is first put up. The device shown in Fig. 1 is a simple belt tension scales which can be built at odd times in any small shop, and will pave the way for belt economies to follow. The idea is to cut new belts short enough to start with, so that a tension is secured at which they will transmit the power calculated and not pull themselves to pieces. The belt clamp and tension scales

combination is brought into play, being tightened until the proper tension is reached, which is 60 lb. per in. width for a single oak-tanned leather belt, 105 lb. per in. width for a double belt, and 150 lb. per in. width for a triple belt.

In other words, if you had a double belt 4 in. wide you would set it so that scales read 420 lb. tension, taking care first to slap the lower part of the belt to equalize the pull in both sides before weighing it. Some people increase these tensions 20 per cent. in a new belt to allow for first stretch. Having obtained the proper tension it is a simple matter to cut the belt off to length and make a joint. If it is a new belt, it would be waste of time to make a cemented joint, and in fact in such cases it is almost a waste of time to make a lace joint. The machine-wired joint which is held together by a rawhide pin is much better for overhead belts and is made in a few moments. Cut a new belt 6 in. short of the measured length as indicated on the belt scales and set in a 6-in. distance piece. If you have on hand a number of these pieces for each width and thickness of belt you can save a good deal of new belting by using these pieces instead of cutting off the leather as it stretches. The idea is clearly shown in Fig. 2.

Although belt tensions will not stay where you put them, because of stretch due to service and changes that come with fluctuations in humidity, if you start right and at regular intervals go over your belts and set them at the proper tension you will be doing something positive about it instead of trusting to luck and the dope pot. In this connection, where possible, head off the tendency to stretch by relieving the tension at night and throwing off the overhead belt when a machine is shut down for some days.

Substitutes for Proper Belt Tension

I may be doing belt dressings an injustice by calling them substitutes for proper tension. Some few of them, it is true, are rather an aid to the full use of proper tension than a substitute. The shop superintendent, however, sometimes looks upon the dope pot as a substitute for more intelligent work, and this may help to account for the alarmingly high belt mortality rates in some shops. The original steer would not recognize his own hide by smell, sight or feeling if his ghost should walk through a shop where it was whirling about overhead covered with compounds.

The real and effective substitute for belt scales in the large or small shop is the intelligent use of idler pulleys. When one of these, properly designed, is installed it not only insures a constantly maintained tension, but, if it is correctly located, will increase the wrap of the belt about both pulleys, which is a big help in itself. The *American Machinist*, Vol. 33, p. 1003, described a remarkable drive at the F. E. Reed plant, where a 5-in. and a 7-in. belt transmitted 136 hp. at 3100 ft. per min., averaging 11⅓ hp. per in. of width. Light double belting was used, and each drive had an idler so placed that the belts made nearly three-quarter full contact. This drive ran 11 years without a dollar for repairs. This speaks well for the use of idler pulleys, especially as the belts in question were much more heavily loaded than any which the small-shop owner will have if he selects them according to the chart on page 446. In locating idler pulleys place them on the slack side of the belt, about one-quarter ways from the driving pulley, to get the best results. Arrange them with a lever or direct weight, so that the tension is kept constant, and then forget that you have any overhead belts until the regular cleaning and dressing day comes around.

Cleaning and Dressing Belts

All belts should be cleaned and dressed every five or six months. If they are coated with caked dirt, a rag soaked in kerosene rubbed over them and followed with a scraper will take it off. If they are oil-soaked, leaving them in naphtha over night will bring the oil to the surface, after which they should be packed in sawdust and left for a week.

Here is a belt dressing which will not injure a belt. It is one which is used by belt manufacturers. It is made of two parts of beef tallow and one part of codliver oil, the

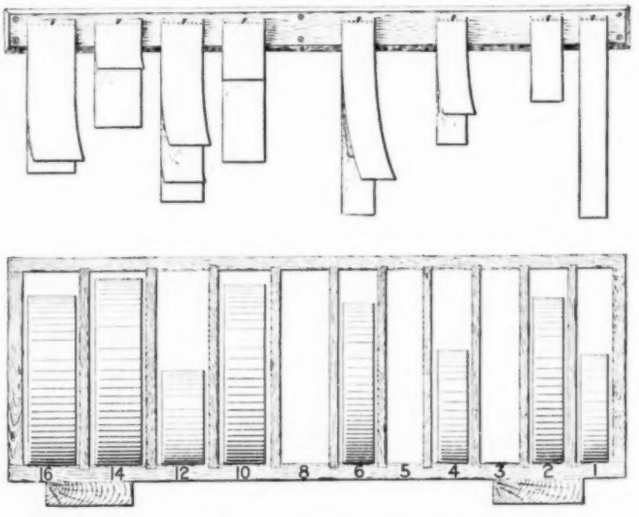


FIG. 3. STORAGE OF NEW BELTS AND OLD PIECES

proportions being by weight. The tallow is melted and allowed to cool until the finger can be inserted without burning it. (Let George try it first!) Then the codliver oil is added and stirred until the mixture is cooled, after which it is ready to apply in light coats to the driving side of clean belts.

While twice a year is enough to dress ordinary belts, there are some which require this more often. For example, belts which run in hot and dusty places become smooth and shiny and should be looked after every three or four months. Neat's-foot oil applied to the *outside* of such belts will help.

Belts should be allowed to wear out only in one way, and that is by transmitting power through their contact with the *faces* of pulleys. Unfortunately, many belts are ruined through rubbing against shift fingers and the side flanges of cone-stepped pulleys. This is in truth burning the candle at both ends, for not only is the belt ruined but power is wasted in doing it. The remedy is to provide plenty of room between shift fingers or to put rollers upon them, and in the case of cone-stepped pulleys to use a belt at least ⅜ in. narrower than the face of the pulley.

A method of storing rolls and odd lengths of belt, which combines neatness with convenience, is shown in

Fig. 3. The short lengths are hung on spikes directly over the bins which contain the rolls of new belting. It is just as easy to put the odd pieces here as it is to throw them into a box, and much more easy to get at the size piece that is wanted.

Checking Up the Cost of Maintenance

To keep belts in A1 condition will cost each year between 14 and 40 per cent. of the first cost of the belting. This will include labor, supplies and renewals. If it is costing you less than 14 per cent. at present, it is a safe bet that your belts are not being kept in A1 condition and that they will fail in much less time than belts which are so maintained. If the small-shop owner has $300 worth of belts in a shop, he must expect to spend at the very least $42 a year in looking after them; and in fact if he gets away with a maintenance cost of 25

BELT RECORD CARD

Location _____

Kind of Belt _____

Make _____

Date Installed _____ Date Removed _____

Length _____ Width _____ Thickness _____

Date		Cost	

FIG. 4. A SIMPLE RECORD FORM FOR THE MAINTENANCE OF SMALL-SHOP BELTS

per cent., or $75 for this quantity of belts, he is doing well, provided, of course, that he keeps them in A1 condition.

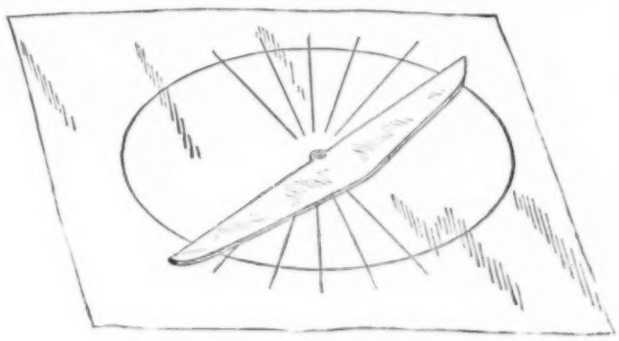
Some will argue that it is much cheaper at this rate to let a belt wear out as fast as possible. This might be true if the cost of the belt were the only matter concerned. The thing that costs you the most money when a belt goes to pieces or fails is not the leather or time required to fix it, but it is the time lost on the machine that is shut down. When belts are kept in proper condition, the stoppages per month should not average over 3 per cent. of the number of belts in use. In other words, if there are 100 belts in the shop, there should not be more than three cases per month where a machine is shut down on account of belt troubles.

There is probably not one small shop in forty that knows what its percentage cost of belt maintenance is. The exceptional ones are those who know how much the total belt expense amounts to. It is far better to have an individual record of the belt, for a total record of this kind is simply a matter of history and will not show you how to have money, whereas individual records will. A simple belt record form adapted to the use of most small shops is shown in Fig. 4, the use of which stands each belt upon its own feet, so to speak, to be judged by what it does.

Home-Made Radial Ruler

By L. M. Simmons

The illustration shows a radial ruler that can be easily made from an old discarded triangle, preferably of celluloid or sheet fiber. It is made with a hole in the center for securely pivoting to the drawing board, using an or-



HOME-MADE RADIAL RULER

dinary thumb-tack or pin on which it rotates freely, and the radial division lines can be ruled very conveniently and accurately to suit requirements.

A Small Duplex Grinder for Manufacturing Purposes

By Ethan Viall

When a company is manufacturing a specialty in large numbers, it is often advisable to build certain machines to suit conditions that are not met by anything already on the market. It was for this reason that the Stenotype Co., Indianapolis, Ind., made the grinder shown in Fig. 1 for use in machining certain parts used in the stenotypes made by them. The machine was made to carry 6-in. wheels normally, and, without attachments, both ends are alike.

As most of the work ground requires a quick traverse and personal attention, the machine is fitted with hand-lever table movement only. The crossfeed, however, has an automatic feeding mechanism, shown in detail in Fig. 2 The hand-lever A swings in a forked bracket B screwed to the knee. The end of the lever is connected to the end of the table at C. When the crossfeed is being used, the table movement causes the two adjustable stops D and E to alternately strike a pin at F. This causes the short lever to rock and operate the connecting-rod G, which in turn moves the shaft H and rocks the lever I. The connecting-rod J joins the lever I and the pawl which engages the ratchet K on the crossfeed screw. By pulling out on the knob L the pin is withdrawn so that the stops do not strike it and the crossfeed does not operate with the table movement. By throwing the pawl that engages the ratchet wheel K into neutral the crossfeed may be operated by means of the handwheel M. The two rocking levers on the shaft are provided with sliding adjust-

ments so that the amount of crossfeed movement may be varied as desired. The table-elevating screw is operated by handwheel *N*.

Some of the Special Fixtures

Felt and leather cushioning pads set in metal holders are surfaced off smooth in the fixture shown in Fig. 3. An emery-faced metal wheel, like a disk-grinder wheel, is placed on the spindle, as shown at *A*. The piece to be ground is then placed in the fixture, the clamp of which is operated by the handle *B*. The handle *C* is next grasped and the work is swung across the surface of the disk wheel. When ground, the holder is swung back free of the wheel and the piece removed.

Another fixture is shown on the opposite end of the machine, and more in detail in Fig. 4. This is used to hold a set of key or finger levers while a strip is ground across them back of the hinge so that they will rest evenly on the cross-support. The levers are first assembled in the comb and are then clamped into the fixture. Another large comb is placed on the back of the levers at *A* to steady them while they are being ground. This view also shows the pad-grinding fixture previously described, with the pad at *B*. This will give a good idea of the way this piece of work is held.

Numerous other fixtures are used with this grinder, but the ones given are sufficient to show the range of the machine and its usefulness for many jobs in a manufacturing line.

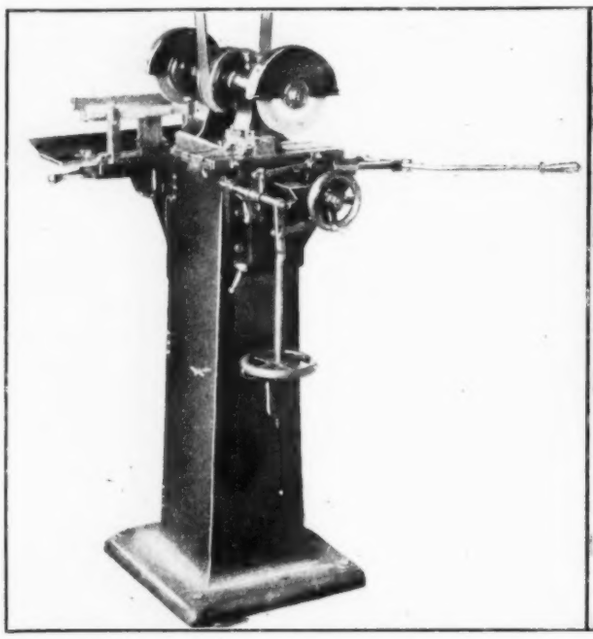


FIG. 1. DUPLEX MANUFACTURING GRINDER

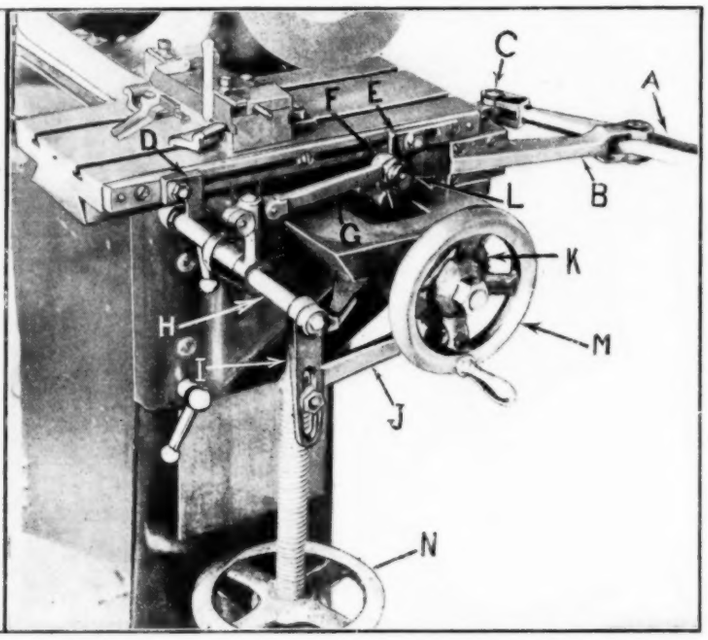


FIG. 2. DETAILS OF TABLE AND CROSSFEED

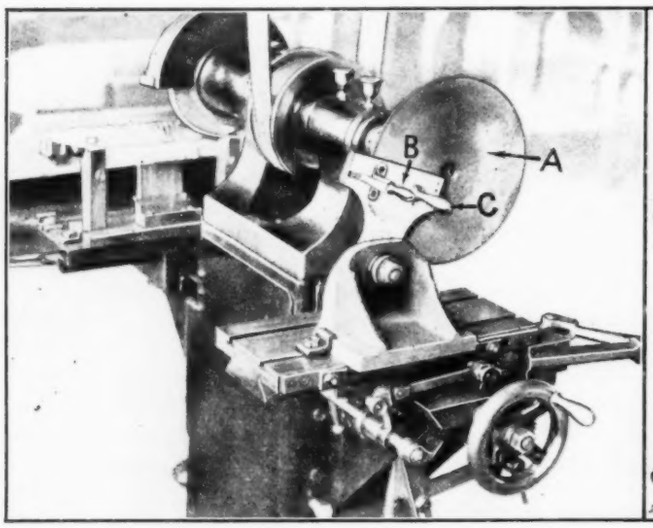


FIG. 3. FIXTURE FOR GRINDING CUSHIONING PADS

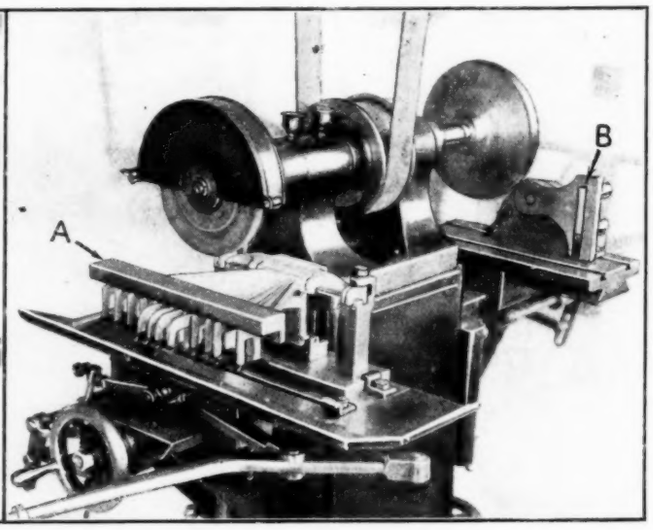


FIG. 4. FIXTURE FOR GRINDING KEY-LEVER BACKS

The Bureau of Standards, at the request of the representatives of the steel industry, has been devoting some time to an investigation of the analysis of steel by spectroscopic methods. It has been possible to show the presence of appreciable amounts of bolybdenum, cobalt, and vanadium in steels said to be free of these elements. No sample of iron has been found free of magnesium or copper, though the amount is small in unfused electrolytic iron. Silicon was not detected in electrolytic iron that had not been fused, but all other irons showed silicon as well as copper, manganese, nickel, cobalt, and chromium.

The Field and Methods of the Corporation School

By E. H. Fish*

SYNOPSIS—The growth of schools for training apprentices, organized and supported by corporations of various kinds, indicates that they are filling a definite place in the educational field. In some ways they offer better opportunities than any other type of school. On the other hand, because they cannot be carried on in the small shop, they do not furnish a complete education for the apprentice. This article reviews the different methods.

If a young man desires to become a sailor, he naturally turns to the sea. He expects there to learn by observation and experience. If he has an inclination to become a machinist, his natural thought is that he can best pick up the trade in a machine shop.

In one way he is right and in another he is wrong. Modern industry is so organized that in many cases the door of progress is locked against the man who would make his way up through the ranks, unless he impresses himself sufficiently on someone who knows and who can set him on the right track. This is not because of jealously guarded secrets, for today most of these exist only in the imagination of those who do not travel and are not conversant with what others are doing, but because so much of what is done in the shops is detached from the engineering work which has preceded it.

The routing of work independently of the foremen has added a barrier to the man who wishes to learn to be a foreman by concealing the efficacy of various methods of manufacture. The departmentalization of work has made it harder for the man who is picking up a trade to get a clear idea of the industry as a whole. Again, there is more need for mathematics and science than ever before, if a young man wishes to "arrive." However, these things are steps in advance which will not be retraced.

A youth realizes these facts and is attracted by evening and correspondence schools. Unfortunately, he is apt to be discouraged in either direction. This is due more to himself than to the school, as it is almost impossible for him to give the concentration to his work that is necessary to accomplish anything. The correspondence school is the hardest to stick to, because there is no time limit. What can be done as well tomorrow as today is usually left until the day after tomorrow, and then never done. Then, too, it is impossible for a great many men to gather in ideas unless they have something tangible on which to lay their hands. Illustrations are helpful, but no illustration has yet been made that wholly takes the place of something to handle. An illustration gives little sense of weight and usually none of color; it gives forth no sound, nor can it be tasted, yet we are educated through these senses at least as much as in any other way.

That this is true is shown by experience in evening-school work. If there is an opportunity for a man actually to do work at a machine or by hand, he will come steadily, while if he is asked to step into a comfortable classroom and offered the elements of mathematics and science through the medium of textbooks, he will soon lose interest and drop out about one-half the time.

The Chance to Do Things

The drawbacks to evening-school work do not lie so much in the fact that the pupil is tired from his day's work, as from the lack of facilities for doing things. A class in gas-engine practice or electric wiring will always hold its own, if the pupils think that the instructor knows anything about what he is teaching. The greatest difficulty, however, is to find instructors who know their trade and who are enthusiastic enough to carry their pupils along with them. This difficulty is enhanced by the fact that almost all evening-school work is either offered by the public schools, where an appointment as a teacher may simply mean a man who must be taken care of on account of influential friends, or by private schools, where the tuition fees must compensate the instructor and where salaries are necessarily small. It goes without saying that those who need instruction most cannot afford to pay enough to allow a competent instructor to have a sufficiently small class to do each pupil justice.

This leaves the young man without any hopeful method of getting ahead in the industry to which he has attached himself, unless his employer comes to his aid. The small boy will undoubtedly be taken care of in an effective way by the trade school. His case is entirely different from that of the young man who has just waked up to the fact that he must make something of himself or sink. It is improbable that the most complete system of vocational guidance will ever change human nature materially. It is natural for a boy who is dependent on himself for nothing more than pocket change, if that, to assume a sort of butterfly existence, as if he could always ask his father for money and get it. A few will realize their position and profit by public trade training—and the few will be so many in actual numbers as to make necessary larger schools of this type than have ever before been built. But the large problem with which this country is face to face is the young man who has gone along until he is 18 to 24 years old without any thought except to get income enough to buy socks and cigarettes, and who suddenly realizes that he is a man and ought to be ready to marry and settle down.

In spite of their drawbacks, the evening and the correspondence schools have done a great deal for the small group of men who are capable of learning by abstract methods. A few (very few) evening schools have offered them concrete work with their hands combined, with a moderate amount of head-work, and have been crowded to the doors. But aside from these few instances, the field is barren except as the employer has come to the rescue.

The employers, and sometimes the organizations of employees, have attacked the problem in one way or another at many times. In past centuries their efforts were manifest in the guilds of the Old World and in the many schools for apprentices which sprang up and died down.

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These different attempts to afford organized training have served their purposes and have either failed for want of intelligent direction or have supplied the need for skilled workmen for the time being and then been allowed to languish until the demand again became acute. The supply of skilled workmen may be compared to the forests of the country. If the trees are cut indiscriminately, the supply gives out years before the new supply can be grown. We are all more or less short-sighted and too ready to let posterity shift for itself.

Corporation Schools to Insure a Supply of Mechanics

Lately, however, there has been a growing feeling that something permanent should be done in this direction. Not a tremendous rush to make mechanics in large numbers, followed by a reversion to inaction, but something that will insure a steady and healthy supply to take the places of those that drop out through old age and to supply the natural increase in the various industries.

The method by which this is being done is known under the general name of "corporation school," not because there is any fixed type of school nor because it is limited to corporations, but because it is a convenient name to use and is fairly descriptive without being committal.

A corporation school may be anything from the old-fashioned apprenticeship to a full-fledged department having shops and classrooms under its control, or it may go one step farther, as is done in the case of the United Shoe Machinery Co. at Beverly, Mass., and get the city to furnish the school work and then pass along one-half of that expense to the state.

There are few places where the old-time apprenticeship plan is carried out by a large concern, either under the name of a corporation school or in any other way. It seems to be generally accepted that specific instruction is needed, rather than example and practice. The first step away from the old system is the setting aside of a few hours of the boy's working time, during which he goes to a classroom to be taught two things, the most important of which comes under the head of civics, and the least important, the mathematics and science of the industry. I say this advisedly, from very extensive contact with the boy question. The misapprehensions that a boy can gather which may influence his life wrongly are not to be numbered. He gets wrong ideas from every direction—from his fellow workmen, who got theirs in the same way; from cheap books, cheap burlesque shows, moving picture shows and everywhere else where an adult will shed the harmful influences. An instructor who can find out what the boys are thinking and can put them where they can pick out the right from the wrong and not be affected by the evil with which they are brought in contact will do more for them and the people for whom they work than he could possibly do through their mathematics—and there is aplenty to do in that direction.

What Is Taught in Classrooms

There are two marked divisions of opinion and practice which prevail, according to the training of the men responsible—one where the work is that of the public schools or of a technical school boiled down, the other the shop approach, which is likely to prevail where the man in charge has come up through the ranks with little formal education. Neither is as successful as a combination of the two. Possibly the various plants of the General Electric Co. may be taken as typical examples of successful classroom work. The boys are divided into small groups which go from one instructor to another. The instructors are from both classes mentioned above, so their tendencies toward extremes, if any exist, neutralize each other. The object of the classroom work is to train the pupil specifically for the work of that industry, but also to train him in a general way to make a good, well-informed, reasoning citizen. In the first case, the corporation school has a great advantage over the public trade school, as it has a perfectly good reason for training its pupils for a very definite if rather narrow end. The public school cannot specialize, because there is no knowing what branch of the industry the boy may decide to follow or be able to get a job at. On the other hand, the public school has a considerable advantage as to teaching general information, which, in the former case, is naturally looked upon as a luxury for boys who are on the payroll and drawing money for the time they spend acquiring it. There is a disposition, however, in the corporation school to expect that the apprentice has had a liberal amount of cultural education in the public schools. The large majority make it a practice to demand that each boy shall be at least a graduate of the grammar schools, and many express a preference for high-school graduates. In consequence, most of the corporation schools confine their cultural studies, if that name may be applied at all, to English and civics.

The Study of English

The English taught is generally limited to what is known as shop English, not that any different language should be spoken in the shop from that used elsewhere, but because English is studied as it is used in the technical nomenclature of the different industries. The most common method of studying English is through shop reports. That is, each boy is required to write a brief review of what he has done in the shop for the previous week. This is treated by the instructor in charge not merely as an exercise in English composition, but as a means of finding out how thoroughly the boy understands what he did. This is not feasible unless the instructor in charge has had opportunity for observation of what the boy has done and understands clearly why he had to do it in the way he did. Then too, it is helpful in both directions at once, because it sets the boy to thinking of what he has done and because it makes it necessary to be primed at all times to tell not only what, but why. His natural tendency is to make his report a mere catalogue of the jobs, from which he must be taught to make an interesting and informative statement that will go into sufficient detail to be understandable and yet not do it so minutely as to be tiresome. When a pupil can write in this way on any subject, it may safely be considered that he has a clear understanding of it.

It is often found desirable to give drills in spelling, not merely the words peculiar to the trade, but very common words as well. This is even more necessary with high-school graduates than it is with those from the lower schools. Very little attention is paid to the reading which the boys do, beyond the selection of articles from the technical papers relating to their trade. In very few schools is there any set course of reading which the apprentices are expected to follow outside of working hours.

In fact, there is little effort made to have them do any studying outside hours.

This seems a little strange because in practically every case they are paid full time for the hours they spend in the classroom, which are, of course, nonproductive for the time being, no matter how much good they may do in the future. It would seem as if they would be glad to reciprocate by studying some during the evenings or, at least, by doing some reading that might be of great help in the way of acquiring general information that would be of value to them, if not to their employers. In the few cases where any outside reading is recommended, it seems to be based on public-school work, which seems to me to be unfortunate. There is an abundance of good literature that is modern and interesting, so that it should not be necessary to make a boy read things which are dead or nearly so. It would seem possible to pick out recent literature without waiting for time to hallow it. It puts more responsibility on the instructor than if he picks old material and then justifies it by citing the fact that it has been used as an entrance requirement for Harvard for the past 10 years, but it is worth the risk.

Teaching Civics and Drawing

Civics is taught in various ways, but in the best schools it is made to center around the shop itself. It is often taught without giving it a name at all, but under the head of shop talks. This is wise because if a textbook is used, it is apt to begin so far from the realities of the apprentice's life that he does not grasp it. If it can be made to start from a discussion of safety devices, hospital service, wage systems, overhead charges and so on, gradually widening until it reaches the relations of the firm with the government, it begins in a way that is vital to the self-interest of the boy and which is bound to open his eyes to the fact that not all business is one-sided. The corporation school is at a great advantage in this regard as compared with the public school, because in the latter the teacher must pick his way so carefully to avoid criticism from political, religious and social sources, which are always at loggerheads, that, by the time he has his course prepared, it is entirely innocuous and will do neither harm nor good. All this the corporation school can cut through at one stroke, and it can teach from its own point of view, which generally seems to be a broad viewpoint in the shops which have such schools. There are very few of the old-school employers left who could see only the selfish side of these questions, so that today there is pretty sure to be a disposition to make the instruction in this subject entirely fair and above-board.

Drawing is the one subject that is common to every school which has any classroom work at all. It is almost invariably mechanical drawing, with some pretense of free-hand sketching, which is too often only a pretense. There is a disposition to teach drawing in the same way as the public schools. This teaches first the principles of projection, whatever they may be, and then a long list of geometric exercises, which far exceeds those a draftsman makes common use of. In some of the more progressive schools there is a shorter course than this, which begins with the making of working drawings of simple objects, throwing in a geometric construction occasionally, as the excuse for it comes up in the work, and teaching the principles of projection first by example and practice. Then comes a little of the development of surfaces, at the last of the training unless the shop work (as in a sheet-metal shop) requires it earlier in the course.

There is a tendency for the drafting room to enlist the services of boys who might otherwise grow up to be useful mechanics in the shop by taking their pick from the pupils who come to them for instruction in drawing. This seems to be a mistake, because it seems as if they often miss larger opportunities in that way and because the shop needs all the bright boys it can get. A very small amount of instruction in drawing is given in some shops and the boy is then sent to the drafting room for a number of weeks. Other shops make a practice of giving quite a little of the classroom time to drawing, sandwiching in the instruction in mathematics with it. This seems a very suitable way to do it, as it seems natural to think of mathematics in connection with the drawing board. In that case, the boy does not go to the shop drafting room for either instruction or practice, unless that is the trade which he is following.

The Problem of Teaching Mathematics

The study of mathematics frequently begins with a review of arithmetic, which, unfortunately, is necessary. The difficulty seems to be that while the boys from the public schools know how to do all the different fundamental problems, if they are put up to them in textbook style, they are totally at a loss when a problem comes to them in shop fashion.

Whenever a problem arises in the shop, there is a great deal of irrelevant detail which must be eliminated from consideration. The public-school boy is sure to think that every item given in the presentation of a problem must be used in its solution, and he will waste hours in trying to make it fit in, where the shop-trained boy will see at once what data he needs and will not be confused by the rest. This phase of the question is usually met by making the classroom problems out of the daily work of the shop, which is not difficult, if the instructor has the run of the shop so that he can pick them up. In a number of places there is a leaning on textbooks that seems unfortunate when the richness of the field for problems that are live ones to the boys is considered. It also gives an opportunity of familiarizing them with their daily work and the product of the firm for which they work. In an electrical concern the number of arithmetical problems that can be given, even though the pupil does not understand them except as rule-of-thumb examples, is so great that it seems absurd for the pupils to be given book examples. These are usually cut and dried and they expect to have them come out even which is something that should excite suspicion rather than inspire confidence.

There is a great deal of disagreement among the different schools as to the amount of algebra, geometry, etc., which the pupils should get. This depends in turn on the ambition of the man in charge and the aim of the course of training. If the man in charge is an engineer, it is hard work for him to restrain himself from trying to build his work up by making it more and more technical. If he does this he neglects the larger number of boys in favor of the few who might have profited by an engineering course in a technical school. If, however, the real purpose of the school in that particular corporation is to discover the young men who may be developed into sales engineers, or for other places which require a technical education, then the object justifies the means.

The larger part of the corporation schools now in existence, however, do not have that aim, but are intended to develop workmen, always with the hope that some of them will advance beyond that stage, but primarily in the hope of building up a better corps of actual producers who will command good wages and lower the cost of production. In a very few instances this difference in treatment is recognized and entirely separate classes are formed from those who are expected to become expert workmen. The cleverer men are assigned to a class with engineering leanings, where mathematics and science is taught them in the conventional engineering-school way. Even that training is of necessity confined to the things which are of use in the particular shop to which the school is attached, and there is a more specific and less broad training than that given in a technical school. This is not altogether a drawback, for the technical graduates scatter into so many branches of engineering practice that their training in school must appear rather superficial when applied to any one specialty. On the other hand, the graduate of the more definite corporation-school course has learned to think more accurately along certain lines, without losing the ability to think for himself along any line.

Since it is customary to teach higher mathematics to the psuedo-technical engineer in conventional style, and as they are most likely to be of the intellectual type which learns most easily in that way, we have only to consider the amount of training in these higher branches which it is found possible and desirable to give to the pupils who only expect to become superior workmen. Needless to say that in detail this depends entirely on the industry in which they are being trained.

Where Mathematics Comes into Play

An apprentice in a printing establishment, who is expected to get an all-round experience as a printer, could hardly find a definite application of trigonometry, and yet he might be able to use quite a little geometry, but not of a kind that the makers of textbooks would recognize. A man may be an extremely good machinist without knowing of anything beyond arithmetic, and yet he might shift to another shop where the drafting room does not do its whole job and find himself confronted with numerous conditions where he could use all the mathematics that the draftsman did in the first shop. That is, a machinist is apt to be able to make use of all the mathematics that a draftsman uses. It is on this basis that many schools use ordinary textbooks for algebra, geometry and trigonometry. On the other hand, it seems as if more satisfactory progress is made in the schools where these subjects are taught in the way outlined above for a review of arithmetic.

It must be borne in mind that the classroom time for these boys is extremely short and that every minute of it must show some results or there will be no total. The work in the schools which do not use textbooks may look crude and unorganized as it is being done, but it is so much more in the line of the apprentice's usual thoughts that he has less of a mental somersault to take when he goes from shop to classroom. In fact, in many places the classroom is purposely as little separated from the shop as possible, and the boys even wear their overalls in class so as to keep them impressed with the unity of purpose of both places. The shop is their laboratory and the classroom is a place where they can think.

It may be laid down as a safe rule that it is unwise to teach any of the higher mathematics to a boy in one of these schools unless an example of the subject in hand can be found in the shop or in the other places where the boy has direct contact. For example, it is unnecessary to avoid teaching the principles of a hydraulic elevator to boys simply because the shop elevator is of the hoisting type, nor is it necessary to avoid discussing the circulation of hot water because the shop is heated by steam. There is probably a hot-water tank in his kitchen at home. But when it is necessary to make far-fetched assumptions in order to be able to give the boy concrete examples, it is likely best to let them alone. It is sometimes difficult for a man who has been able to profit from the training offered in our schools to see that there may be other types of minds than his own—minds which may be just as alert and just as valuable to the world as his, but which respond slowly to abstract reasoning and yet quickly grasp that which they can get at through their other senses. It is not necessary to carry this to extremes. After a boy has been running a lathe a few days, his instructor can talk with him about a tool post or a faceplate without having one in his hand.

Applying Science to the Shop

Science is taught in almost every school that has classroom work at all, but in hardly any under that name. In some it is taught as a sort of shop intelligence. For the small number of classes for engineers, it is taught in the technical-school way; but in most of the schools it is treated as a number of more or less isolated natural phenomena which are either interesting as general information or desirable for use in that industry.

One of the most common subjects which comes under this head is that of measurements. Almost every industry uses some form of measurement. A printer's type is a measuring system in itself, a very simple one, but one which it saves time to teach the apprentices rather than have them gradually worry it into their minds. It is likewise less expensive to teach a group of boys to read a micrometer and vernier in a classroom than it is to let their machines stand idle while the foreman gives his time to each individual.

Another subject that is common to all the schools is the study of the materials used in the trade. This is especially important in places like a printing office, where the stock is often left to the printer, and in shops where there is a considerable variety of material that must be machined or heat-treated in different ways.

Mechanics and mechanism is perhaps the next most necessary subject. In almost every imaginable industry there is machinery which must be adjusted and kept in order. This is usually done by a study of the actual machines brought into the classroom and dissected by the boys.

The next most taught subject is electricity. This is an essential nowadays in many industries owing to the amount of electrical transmission used, and it is a matter of general interest to all boys. It is so easy to teach on that account that the method to be used makes little difference, except that there is always a temptation to skimp the groundwork and go too directly to the applications.

Sound, light and heat are rather lightly dwelt on in any of the schools so far established, though it is easy to see that industries may join the ranks in which each

one of these may be the most important branch of science. A telephone manufacturer or a talking-machine manufacturer might have occasion for his employees to know quite a bit about acoustics, and a manufacturer of optical instruments might wish to train young men in the science of refraction and reflection of light. A manufacturer of steam boilers or of economizers, etc., might also need to give instruction in heat. All these things tend to specialization, and while it may not be possible in the short time which can be allotted to the classroom work to try to do much with things which lie outside the scope of the work of the particular shop, the apprentice has the satisfaction of having a more thorough and practical grounding in what he is taught. The training ought to make it possible for him to get the other things by himself, if he changes jobs. In fact, the prime object of any school should be to put men in a position to carry on their own education.

Handling the Shop Work

Three distinct methods of handling the shop work are in use. The first is the nonorganized method by which the boy is dumped into the shop under some complaisant foreman, and forgotten. His state is no better than under the old apprenticeship system. If he pulls through, it is the survival of the fittest and no credit to the shop. The second is the establishment of a department in which all apprentices are taught to do the work of the shop by men who are primarily instructors and after that foremen. This is theoretically the best, but complaint is often made that the boys having only each other's examples to follow do not acquire rapidity of action and that they have to be brought up to speed by painful means after they are once in the shop. The third method is a combination of the two. The boys are in a separate training room long enough to have obtained a fair idea of shop processes and to have formed habits of a correct kind, and then they are sent out gradually into the other departments of the shop, where they mingle with the men. Personally, I know of only a few shops where the men who are supposed to be journeymen extend themselves to a faster pace than can be maintained in the apprentice room, if the instructor himself is geared to the right ratio.

There is a modification of the first scheme by which the boys are distributed about the shop under different foremen, and there is also a man whose duty it is to keep himself informed about the work they are doing. He also follows them up to see that each gets as good instruction as possible and that they are shifted about as rapidly as they should be. Whether any better results are obtained by this method than would come from this man devoting the same amount of time to instructing them himself before they were turned into the shop is an open question. In a place like the Fore River Shipbuilding Co., where some 25 different trades are practiced and most of them are represented in the school, no one man could do a great deal for his pupils in the way of direct training for each trade. In such places this scheme of following the boys up is probably the most feasible solution. Where boys are distributed about the shop and each one has a given program which is to be followed out, some scheme of either a card index or a chart is necessary so that it can be known at a moment's notice how long each boy has been on each assignment and what assignments remain for him. Where a regular program is made out for each boy to follow, this can be done by means of a board and some numbered pegs, which can be placed in holes as the boys reach each stage of their progress. Where, as is quite commonly the case, a boy is not moved to the next department until the foreman is satisfied that he is fitted to leave his, this becomes somewhat more complicated and it may be kept better on a card index.

There is no question but that definite records of the boy and his progress, not only in the classroom work, but in the different parts of the shop, are necessary not merely as an index of his aptitude, but as an indication as to the direction in which he may expect to specialize with profit. It is the practice in many shops not to indenture the boy in any way whatever. In some places a reward is offered if he completes the course, but in many it is expected that the boy will stay in the class only so long as he appears to be profiting by it and then he is given a regular job in the shop. In this way, if a young man has a capacity which limits him to becoming only an operator and he is satisfied to stop there, no objection is made to his stepping out of the class when he is ready to develop along that narrow line. In a case like this, the school is laid out so that the boys who do go through the course are bright young fellows who show promise of rising above the level of workmen and becoming gang bosses or something still higher.

The Length of the Course

The length of the course is usually either three or four years. Classroom work occupies from nothing up to 10 hr. per week, the average time being four hours. This is a very brief time in which to make any showing. Where it is concentrated into a single half-day with entire rest from study for a whole week, the progress of the pupil is a sort of ratcheting in which he slips back nearly as much as he goes forward. Just what is the best division of time is uncertain, but as a matter of psychology, it is likely that anything over two hours at a time will result in a mental slowing down that is anything but effective. The fact that no game that boys play is supported by them if it takes over two hours to play it is a pretty good sign that their capacity for concentrated attention, even on something about which they are enthusiastic, is limited. A single hour is almost as objectionable as the long time because of the waste in cleaning up when going from the shop to the classroom.

Just how many young people are profiting from this work at this time is hard to tell. A year ago the railroad schools that are members of the national society reported in the vicinity of 5000 boys and the manufacturing concerns reported about 3000. To this should be added a considerable number of stores and other commercial organizations which are doing much for their girl employees by themselves and, in some instances, with the coöperation of the city in which they are located. The total number affected must be close to 15,000, but even that is only the merest drop in the bucket.

The reasons for the smallness of the number are many. For one thing it is a comparatively new idea. To be sure, a few shops like Brown & Sharpe saw the light a good many years ago, but they set their example so high above the trend of the times that it had almost no effect then. Now they are beginning to be copied, and their experience is considered extremely valuable. Another drawback has been the question of size. A small shop, or one with

less than 200 men, can do nothing with it. It may join a society, but unless some one of the firm is very enthusiastic about it and is willing to give freely of his own time, it is a burden. The very large corporations, the ones that need it the most, are by no means all so open-minded as the Westinghouse and the General Electric companies. As they fall more and more into the hands of the younger generation, there is greater chance that they will see that the cost of running a school is only a deferred profit.

The cost seems to be indeterminate. If it is necessary that the entire time of the instructor, or instructors, shall be given to the school and if strict account is taken of all the expenses incidental to its operation, including rental of space and power, its share of taxes, etc., it probably will show a permanent deficit. If, on the other hand, it is treated as an overhead charge itself and not made subject to overhead charges of its own, then it may appear to show a profit. The real profit, however, comes from the fact that it insures a supply of young men who have an intelligent knowledge of the firm's methods of manufacture. It may be that many of the graduates will leave the shop soon after completing the course, but that may be an excellent thing for both the shop and the boys. They will be gaining added experience and breadth of knowledge, and yet they will always be available at any time when the home company needs their services at the increased value which it has itself given.

Shell-Socket Assembling Tool

By George Armstrong

The accompanying illustration, Fig. 1, shows the general arrangement of a brass-socket assembling tool used in the manufacture of the 18-lb. British shrapnel shells. Details are given in Fig. 2 and full instructions as to its use follow:

To screw in the partly finished socket, screw the center plug *A* through the outer nut *B* until it rests against the pin *C*. Then screw the plug into the socket *E*, turning *A* right-handed. When it bottoms in the socket turn back

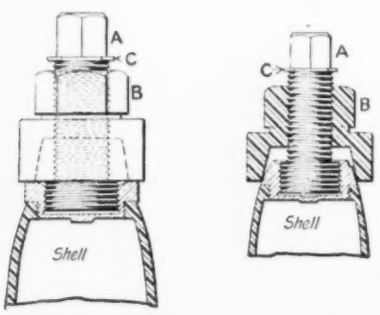


FIG. 1. GENERAL ARRANGEMENT OF SHELL-SOCKET ASSEMBLING TOOL

the plug *A* about two threads, and then turn the nut *B* left-handed until it rests on top of the socket *E*. Thus the socket is gripped by both the plug and the nut. Now place the wrench *D* on *A* and turn right-handed. By the action of the right- and left-hand threads the socket can be screwed down tightly without injuring it in the least.

To release the tool from the socket place the wrench *D* at *B* on the outer hexagon and continue to turn right-handed. The tool will be released quite easily.

To screw out the socket *E* screw in the center plug *A*, place the wrench *D* at *B* on the outer hexagon and turn left-handed. The socket will be released with ease. The instructions are the same in cases where the finished sockets must be removed and replaced again to rectify faulty weights.

The single-handed wrench is used to release the tool from the finished socket after removing the latter from the shell, to rectify faulty weights, and so forth. When

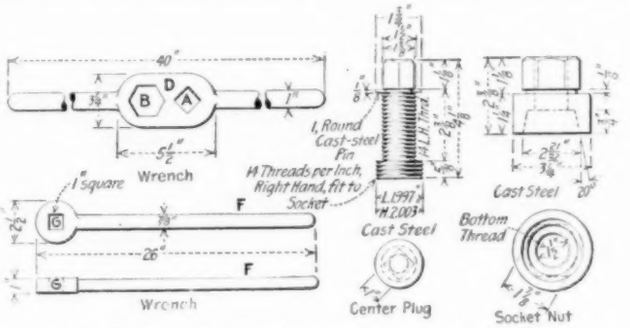


FIG. 2. DETAILS OF SHELL-SOCKET ASSEMBLING TOOL AND WRENCHES

the socket has been released it is found that it is held quite tightly in the tool. By placing the wrench *F* on the plug *A* and turning left-handed, at the same time having the wrench *D* on the hexagon nut *B* and holding against the wrench *F*, the tool will be freed.

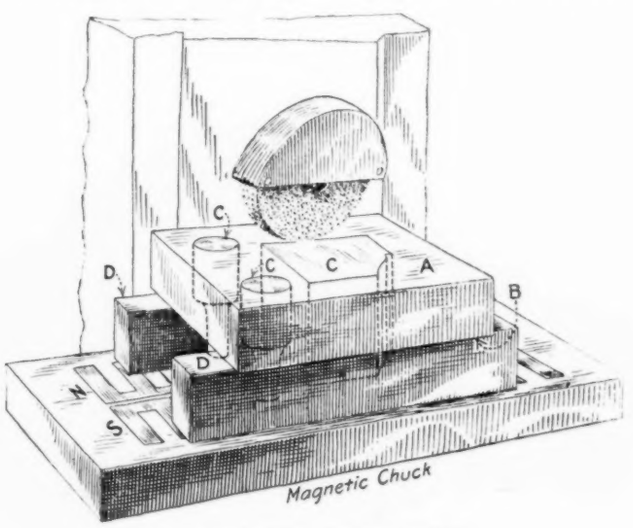
I am using the tool daily and it has given better satisfaction than any other I have yet used. The brass is not injured by the application of the tool or the threads expanded or spread, as I have proved by experience.

A Magnetic-Chuck Kink

By Charles Weston

Sometimes a die maker wishes to surface-grind the back of a punch-holder, as at *A* parallel to the under surface *B*, especially the back of punches as at *C*, which remain more or less above the surface *A* after riveting.

If the punches do not project more than 2 in., all that is necessary is to lay a pair of parallels *D* underneath



A MAGNETIC-CHUCK KINK

the holder with one on each pole of the magnet chuck. Few die makers seem to know that poles *N* and *S* can be extended to such a height.

Tools for Making the Dayton Cam-Gear Case

By Robert Mawson

SYNOPSIS—In this article are described the tools used for machining the cam-gear case and cover. The case casting is first machined with a register, which is used as a locating medium in the subsequent operations. The first machining operation on the cover is milling. Afterward the gear-shaft bushing holes are drilled and reamed. Pins that fit these reamed holes are then utilized to locate the part for the subsequent drilling operations. The tools shown are of modern design, yet have been tried out sufficiently to prove them efficient as regards both quality and quantity of production.

The Dayton Motor Cycle is manufactured by the Davis Sewing Machine Co., Dayton, Ohio, and in this article will be described the tools used in making the cam-gear cases.

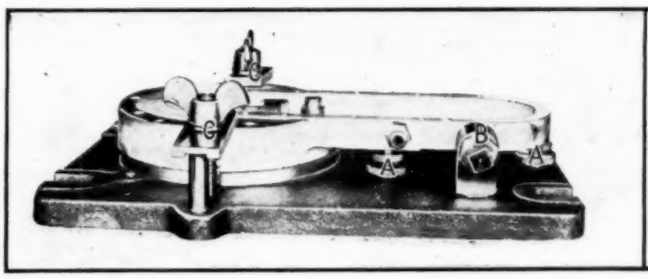


FIG. 3. MILLING THE GEAR CASE

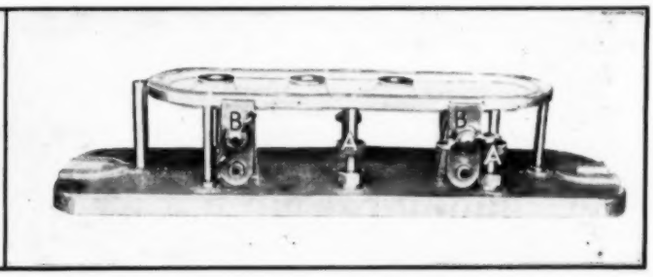


FIG. 4. MILLING FIXTURE FOR COVER

One of the finish-machined cam-gear case covers is shown in Fig. 1 and one of the cases in Fig. 2.

The first machining operation in making the gear case is facing and turning the register. For this the casting is held in a three-jawed chuck on a lathe, and the work is performed in the usual manner. The approximate time required per case is 18 min.

The casting is then machined on the outer surface in the fixture shown in Figs. 3 and 3-A. The piece is located by a recess into which the machined register is placed. Three screws, as *A*, are tightened under the casting to hold it against the machining stresses. The sides of the part rest between a pin at the rear and the screw *B*. The two straps *C* are then tightened down by means of the thumb-screws to hold the casting securely. The fixture is located by tongues and held down with bolts to the machine table in the usual manner. The machining operation is performed with a 4-in. inserted-tooth milling cutter operating at 90 r.p.m. with a feed of 0.02 in.

In milling the cover the fixture shown in Figs. 4 and 4-A is used. For this operation the casting is placed on fixed pins, and adjustable pins, as *A*, are screwed up to support it uniformly over its entire surface. Two clamps *B* are tightened by means of the thumb-screws shown, to hold the piece securely. The fixture is located by tongues and held to the machine table with bolts in the usual manner. In machining the cover a similar cutter, operating at the same speed and feed, is used as when machining the case, already described.

The jig used for drilling holes on the outer surface is shown in Figs. 5 and 5-A. The casting is located by a recess to suit the machined register and a ½-in. pin to fit the reamed intermediate gear-shaft hole. The support *A* is afterward screwed up to hold the part in alignment. The cover *B* is dropped down and held with the thumb-screws *C*, and the knurled-head pins *D* are tightened on the casting to hold it securely in the jig. Twelve No. 29 and six No. 10 holes are then drilled.

The No. 29 holes are later tapped with No. 8-32 threads, and the No. 10 holes are counterbored to suit fillister-head screws. It will be observed by referring to Fig. 5-A that the jig is fitted with a pipe through which lubricant is forced by the machine onto the revolving drills.

For drilling the bushing holes for the shafts in the cover the jig shown in Figs. 6 and 6-A is used. The casting is

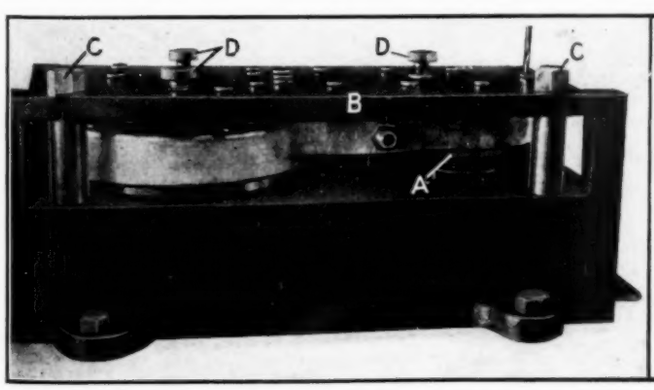


FIG. 5. DRILLING THE SCREW HOLES IN CASE

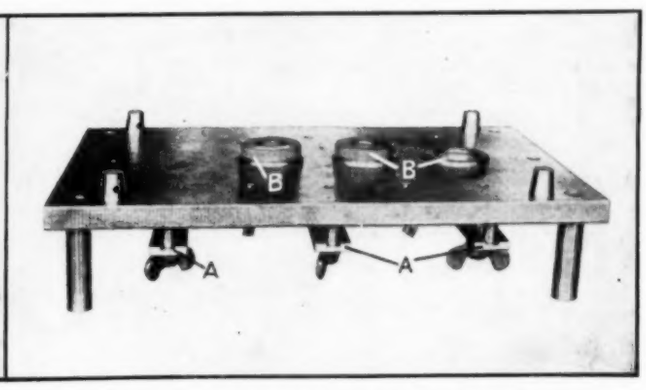
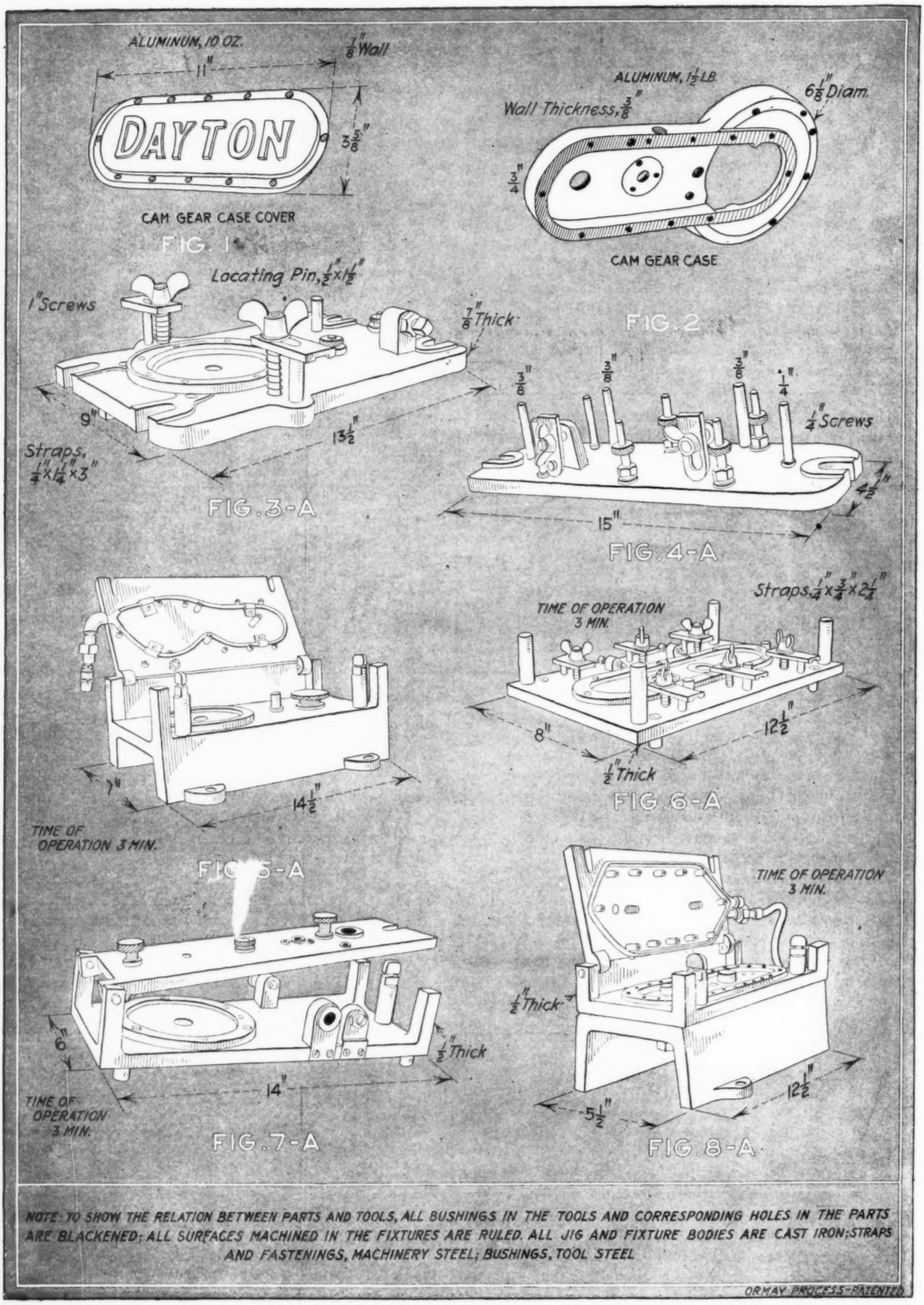


FIG. 6. DRILLING SHAFT HOLES IN COVER



DETAILS OF JIGS AND FIXTURES USED IN MAKING CAM-GEAR CASES

placed on a steel pad and pushed against locating pins by screws on the sides. Six clamps, as *A*, three on each side, are then tightened by means of the thumb-nuts shown. This holds the casting securely in the jig. The tool is next turned over to the position shown in Fig. 6. Three $^{45}/_{64}$-in. holes are drilled through bushings at *B*. Other slip bushings are then inserted in the fixed bushings and the holes reamed to $\frac{23}{32}$ in.

The jig used in drilling the gear-shaft holes is shown in Figs. 7 and 7-A. The casting is placed in a recess that fits into the machined register. The other end is

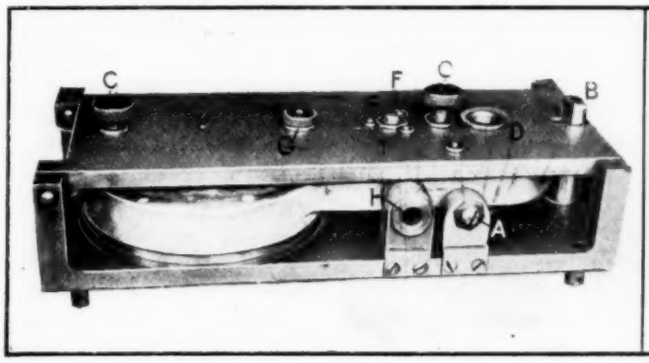


FIG. 7. DRILL JIG FOR SHAFT HOLES IN CASE

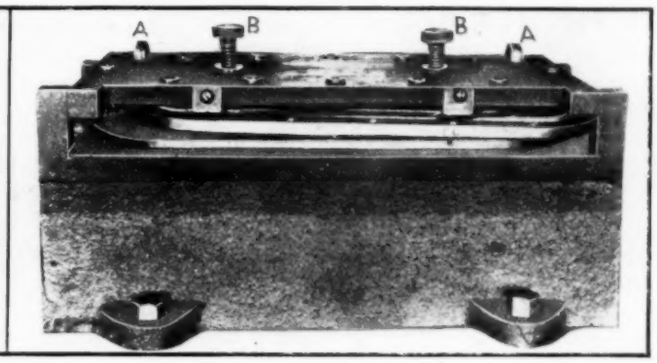


FIG. 8. DRILLING SCREW HOLES IN COVER

supported by an adjustable knurled support. The part is located by being forced back against the inner end of the adjustable screw *A* with a knurled screw. The cover is dropped down and held with the thumb-screw *B*. The knurled screws *C* are then tightened on the casting to hold it securely in the jig. The following holes are machined: One $\frac{5}{8}$-in., drill at *D*; one $\frac{1}{2}$-in., spot drill and ream at *E*; three No. 27 at *F*; one $\frac{3}{16}$-in. at *G*; and one $^{29}/_{64}$-in., drill at *H*. The $\frac{3}{16}$-in. hole is later tapped with $\frac{1}{4}$-24 U. S. fine thread and the $^{29}/_{64}$-in. hole tapped with $\frac{1}{4}$-in. pipe threads.

In drilling the clearance holes for the screws in the cover, the jig shown in Figs. 8 and 8-A is used. The casting is located by two $\frac{23}{32}$-in. pins that fit into holes previously reamed. The cover is then dropped down and fastened with the thumb-screw *A*. The knurled-head screws *B* are afterward tightened onto the casting to hold it securely in the jig, and twelve No. 8 holes are machined, the drills being guided through bushings in the jig cover.

The cover is then raised and the holes counterbored to suit the heads of the fillister-head screws. It will be observed by referring to Fig. 8-A that a lubricating arrangement is provided with the jig similar to that described for the gear-case jig shown in a previous illustration.

Controlling the Manufacturing Expense

By F. S. Martin*

Indirect expense may be divided into two parts, namely, manufacturing and commercial, and these may in turn be subdivided. It is the purpose of this article to set forth a method of controlling certain items of the manufacturing expense, more particularly those for which a superintendent or departmental head is wholly responsible.

*Superintendent of industrial motor department, Westinghouse Electric and Manufacturing Co.

Manufacturing expense may properly be divided into three classes: (1) Items of fixed expense which are unchanged from month to month; (2) items of variable expense not under the control of the departmental head, and for which he is therefore in nowise responsible; (3) items of variable expense directly under such control, and for which he is therefore, wholly responsible.

Belonging to Classes 1 and 2 are such items as rent, insurance, taxes, heating, sanitary equipment, water, fuel, fire equipment, telephone, telegraph, engineering and drafting, buildings and building equipment, handling machinery, power generation, office supplies, etc., and which it is obvious are beyond the jurisdiction of the departmental head.

Omitting further reference to these classes, there may be mentioned as typical of those embraced within Class 3, with which this article has more particularly to do, such expenses as wages of foremen, production and time clerks, janitors; new small tools and equipment, lubricants, waste; maintenance of machine tools, benches and small tools; electrical and mechanical equipment, and so on.

Having properly classified these expense items, it is next necessary to establish some basis or goal in connection with their total cost and with the cost of each, the attainment of which in the department will be considered satisfactory by the management.

TABLE 1. METHOD OF COMPUTING UNIT OUTPUT TIMES

1915	Month	Units	Hours	Average	
Prior 5 months, July to December		34277	3 [illegible]	1.01	Use for both January and February estimate—see text.
Less	July	2,208	1,91		
		32,069	32,376		
Add	January	5,076	5,140	1.01	Use for March estimate.
6 months		37,145	37,516		
Less	August	7,635	9,177		
		29,510	28,399		
Add	February	5,113	4,899	.96	Use for April estimate.
6 months		34,623	33,238		
Less	September	6,759	5,093		
		27,864	28,145		
Add	March	5,683	5,737		
6 months		33,547	33,882	1.01	Use for May estimate.

The control of these departmental expenses means of course that they must be kept within certain well-defined limits, depending on the rise and fall of production or output; and as in perhaps the large majority of manufacturing establishments it is customary to calculate indirect expense as a percentage of the productive labor, this method will accordingly be considered here. Such being the case, it will be appreciated that if the department

is to be held responsible for such expense, it must be advised by the management as to the production or output required from the department for a given period; the ratio of total productive labor to total payroll of the department for satisfactory performance; the expense items for which the departmental head is to be held responsible, and the ratio of total of such expense items to productive labor of the department for satisfactory performance.

The ratio of total productive labor to total payroll of the department will in large measure be based upon past performances in this respect; but if it is felt by the management that the department can do still better, the ratio should be changed accordingly. Having settled upon this ratio, and in order to estimate the productive labor required to produce the output desired, the total payroll of the department must first be estimated. This can be arrived at as follows:

The average hourly rate of all employees in the department, excluding monthly men, is computed, regardless of the wage system in use; similarly, the average time in hours which has been required to manufacture a unit of output in the department is ascertained. This average time per unit of output is obtained by dividing the total hours worked by all hourly rated employees in the department during a given period by the total units of output in such period. Knowing the units of output expected by the management for the following month, the total payroll required for such output can readily be estimated from the average time in hours heretofore necessary to manufacture a unit of output and the average hourly rate of all employees. Having estimated the total payroll of the department in this manner, the productive labor can then be estimated for the month, since from the departmental records of past performance the average ratio of productive labor to the total payroll is known.

Applying now the method just outlined to a practical example, let it be assumed that 5660 units of output are required to fill orders for the coming month of March, and further that the management has set the productive labor at 80 per cent. of the total payroll of the department, and the expense items for which the department is to be held responsible at 50 per cent. of such productive labor, if satisfactory performance is to be attained.

The average time which has been required heretofore to manufacture a unit of output is computed from the departmental records in the manner herewith indicated in detail in Table 1, and as will be readily noted is the average of six months' performances.

Having ascertained the average time actually required to manufacture a unit of output during the preceding six months but one, August to January, this time, 1.01 hours, is set down in the proper column of tabulated data (Table 2) as the estimated time required per unit of output for the month of March. In this connection it should be particularly noted, however, that the average time thus used is the average not for the preceding six months but, as stated, for the preceding six months but one. The reason for this is at once understood when it is appreciated that all estimating must be done at least a few days before the end of each month, and therefore the data for the passing month are not yet available. For example, the estimating for March must be done during the latter part of February, but as the February records have not then been completed, the estimating must therefore be based on performances ending with January. Next, since the maximum number of working hours in each month are known (March = 245¼ hours), and as the number of units of output required (5660) have been designated, both of these figures may likewise be set down in their respective columns. The total estimated time in hours necessary to manufacture the designated number of units of output is now easily figured, for the average time required per individual unit of output has already been computed.

Having estimated the total hours required to manufacture the designated output, and knowing the maximum number of working hours per month, dividing one by the other will give the estimated number of men required, which number can be increased if desired to allow for absences or for slack periods when it may become necessary to work the men part instead of full time. The earned hourly rate of the department, exclusive of monthly men, is ascertained from the departmental records in much the same manner as is the average time per unit of output, and having it and the estimated total number of hours required, the total estimated payroll can be figured.

TABLE 2. HOW THE ESTIMATES AND ACTUAL RESULTS CHECK

1915, Month	No. Hr. in Mo.	Parts Req'd		Time Each		Total Hours Required,		No. of Men,		Hours per Man,		Average Earned Rate,		Payroll,	
		Est'd	Act.	Est'd	Act.	Est'd	Act.	Est'd	Act.	Est'd	Act.	Est'd	Act.	Est'd	Act.
Jan.	216	5,200	5,076	1.0	1.01	5,200	5,140	30	33	153	156	.27	.262	1,404	1,348
Feb.	201	5,100	5,113	1.0	.96	5,100	4,899	33	34	154	144	.268	.26	1,366	1,273
Mar.	245¼	5,660	5,683	1.01	1.01	5,716	5,737	33	32	173	179	.262	.27	1,498	1,553
Apr.	235½	5,740	6,136	.96	.96	5,510	5,895	33	32	167	184	.26	.268	1,433	1,578
May	221¼	5,740	6,187	1.01	.97	5,797	6,026	33	29	175	207	.27	.274	1,565	1,653
Total		27,440	28,195	....	....	27,323	27,697							7,266	7,405
Average		5,488	5,639	.996	.982	5,464	5,539					.265	.267	1,453	1,481

In the example under discussion the allowance for productive labor for March was figured at 80 per cent. of the total estimated payroll; it is therefore $1198.40. Similarly, the allowance for departmental expenses was figured at 50 per cent. of the estimated productive payroll, and it is therefore $599.20. The latter amount should now be divided among the expense items for which the department is to be held responsible. Having made this division, based usually on past requirements, it then becomes necessary to see that such assignments are not exceeded, which may be done by carefully estimating the cost of each proposed expenditure before authorizing it and checking against the proper individual expense allowances, so that each will always be kept within bounds.

The preceding method is one of averages, and hence it follows that the longer it is in use, the more nearly exact will be the calculations. It is in no sense offered as a scheme of universal applicability, or even of application to items of manufacture which undergo marked changes in size or the equivalent from month to month—as, for example, a small number of units of large size one month to be followed by a large number of units of small size the succeeding month; but, that it has a distinct field of usefulness and one of considerable range is shown by its successful working in one of the largest industrial plants of this country.

Linkwork Problems--Velocity and Force Relations*

By F. A. Halsey†

SYNOPSIS—A simple explanation of how to lay out linkwork with certain velocities or force relations between its parts. This method has many useful applications and should be understood by everybody in the drawing room. Several common constructions are used to show its practical application, including the Whitworth quick-return motion, the slotted-arm quick-return motion, and the common and double toggle joints.

Cases frequently arise in which it is desired to lay out a piece of linkwork with certain velocity or force relations between its various parts. An example of the former is found in the quick-return mechanisms of shapers and of the latter in various toggle-joint mechanisms, such as those of compressed-air riveting machines. In the shaper mechanism it is desired to give as uniform a velocity as possible to the cutting tool with as high a return velocity as is feasible, while in the riveter mechanism it is desired to have the closing pressure on the rivet exceed the pressure on the piston by a determined ratio.

The most satisfactory method of doing this is by the Reuleaux analysis, which is purely graphical and easily learned. This analysis is the foundation of many textbooks on mechanism—of practically all that have been published during the past twenty or thirty years—but nevertheless its progress in the drawing office, where it has many useful applications, has been surprisingly slow. This article is an attempt to explain its principles and to show its application to practical problems.

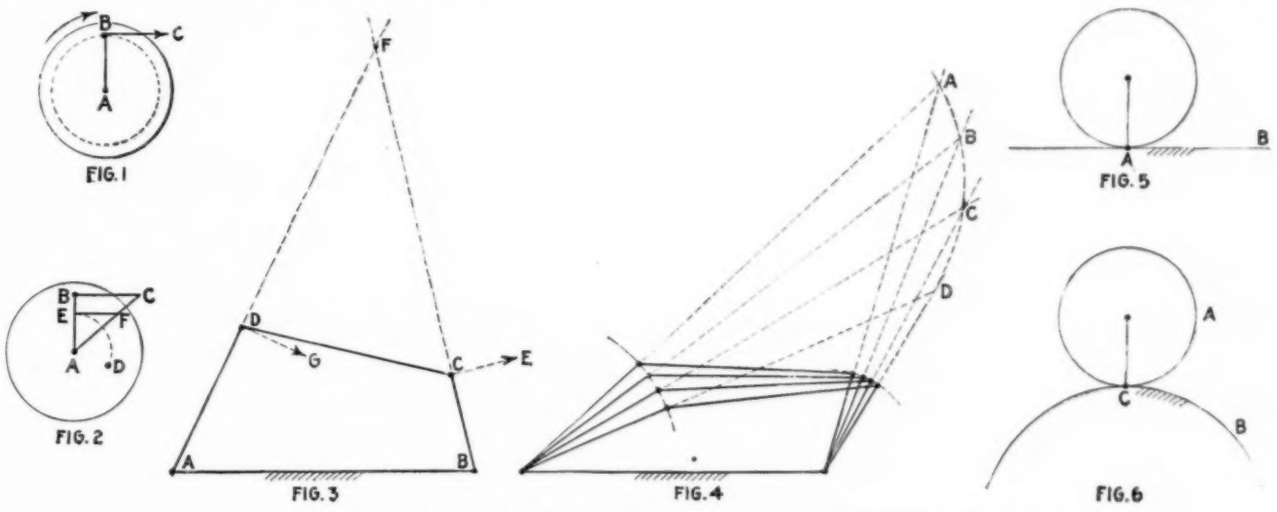
In doing this some of the later developments of the method will be ignored, because of the increased effort required in learning them. In solving problems of this kind, which the average man has to do occasionally only, a method that is easily learned is preferable to one that requires more study and mental effort, even though the former may require the drawing of a few more lines than the latter.

Elementary Principles

The method grows out of a few facts that are so simple in their usual application as to be self-evident, but being less obvious in this connection, they are given here in order to refer directly to them.

Let Fig. 1 be a disk revolving about its center A. At any moment, the direction of motion of any point B of the disk is that of the perpendicular BC to the radius AB. Therefore, if the direction of motion is known, we have the first of these principles:

(A) The center of motion of any moving point is located in a line drawn through the point and perpendicular to the direction of motion. If the point moves in a straight line this statement still holds true, with the proviso that the center of motion is at an infinite distance.



FIGS. 1 TO 6. DIAGRAM ILLUSTRATING THE INSTANTANEOUS CENTER

Other principles are:

(B) The velocities of all points at the same distance from the center of motion are equal.

(C) The velocities of points at different distances from the center are to one another as those distances.

From (B) and (C) we obtain a graphical method of finding the velocity of any point from the known velocity of any other point of a revolving disk as follows:

(D) The velocity of point B, Fig. 2, being represented to scale by the length of the line BC, to find the velocity of point D, draw the arc DE from the center A, draw AC and, through E, EF parallel to BC, and EF is the velocity of D.

The Instantaneous Center

Fig. 3 represents by its center lines the classical four-link mechanism of Reuleaux. Any link of this mechanism may be fixed, the effect of fixing different links on the motion of the parts being fairly startling. In the

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†Editor Emeritus, "American Machinist"

figure link *AB* is supposed to be fixed and is so indicated, as it always is in the Reuleaux analysis, by the short section lines leading from it. In actual machines link *AB* is the frame which, in this analysis, is always represented in this manner by a straight line connecting the points, or pins, and having short section lines leading from it.

In this mechanism links *AD* and *BC* turn about the pins *A* and *B* and our first consideration is the character of the motion of link *CD*. The pin *C* is a part of both links *BC* and *CD*. Its motion is determined by the fact that it is part of *BC*, the direction of that motion being the arrow *CE* perpendicular to *BC*. As it can have but one motion, its direction of motion when considered as part of link *CD* must also be this arrow *CE*. By principle (A) the center of its motion as part of link *CD* must be somewhere in a line *BF* through *C* and perpendicular to *CE*. Applying the same reasoning to pin *D*, its center of motion when considered as part of link *CD* must lie somewhere in a line *AF* through *D* and perpendicular to *DG*. Now the link *CD* being a rigid body, it moves as a whole and all points on it must turn about the same point. Since that point for one end of it lies in line *BF* and for the other end of it in line *AF*, the single point about which the entire link, for the instant, turns must be at the intersection *F* of these lines. This point was named by Reuleaux the instantaneous center. Others have called it the instant center, the virtual center and the centro.

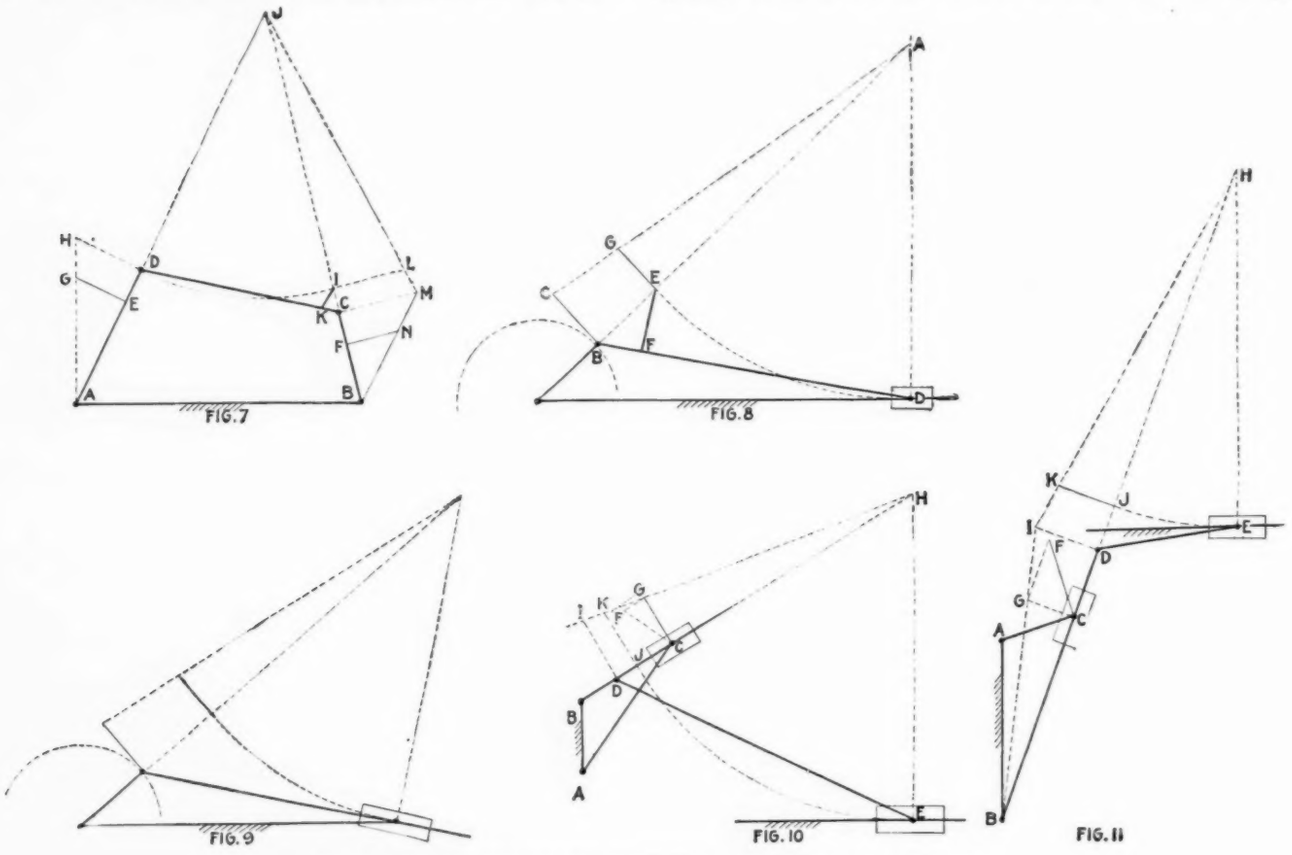
It will be observed at once that for every position of the parts a different instantaneous center will be found. Four such centers are found in Fig. 4. By drawing a smooth curve through them we obtain the path *ABCD* traced by the instantaneous center in its movements, which path Reuleaux named centroid.

Simple Illustrations of the Instantaneous Center

The conception of the motion of this link as a turning motion about a center that is itself in constant motion requires some mental effort, and this effort is made easier by reference to common constructions in which the motion is simpler.

A vehicle wheel, Fig. 5, when rolling on the ground turns at any instant about the point *A* in contact with the ground, and this point moves forward with the wheel and traces the line *AB*. For any position of the wheel this point of contact *A* is the instantaneous center for that position, and the path *AB* traced by it, that is, the ground line, is the centroid of the wheel. Similarly, a circle *A*, Fig. 6, rolling on a second stationary circle *B* turns at any instant about the point of contact *C* of the two circles, which point of contact is the instantaneous center, and the stationary circle is the centroid. The essential difference between these cases and that of the link is that in these cases the instantaneous centers are obvious and the centroids are the simplest of curves which are easily drawn, while in the case of the link the centroids are complex curves which can be found only by construction. A little consideration of Fig. 4, imagining the link to move from position to position as drawn, will now make clear the fact that its motion, like that of the vehicle wheel, is one of turning about a moving instantaneous center.

This conception is true not only of this link, but of all possible motions in a plane, all of which may be regarded as turning motions. In the case of such parts as pulleys and gears the centers are fixed, while in others



FIGS. 7 TO 11. DIAGRAMS SHOWING VELOCITY RELATIONS

the centers themselves move, the case of the link being but an illustration of a universal truth. This conception is the foundation and the leading feature of the Reuleaux analysis.

The Velocity Relation

Suppose, now, we have given the velocity of point E of link AD, Fig. 7, and wish to find the velocity of point F of link BC. Representing the velocity of point E by the length of the line EG and applying principle (D), we find the velocity of point D to be the length of the line DH. Drawing the arc DI from the instantaneous center J, we obtain the point I. If this point were carried by a short arm IK projecting from link CD, it would, by principle (B), have the same velocity as point D. Laying down IL equal equal to DH and again applying principle (D), through the triangular construction from instantaneous center J, we find the velocity of pin C to be CM. Repeating the construction again from center B, we find the required velocity of F to be FN. These simple constructions are all that are required in similar cases.

The force relation is given at once by the principle of virtual velocities, which tells us that the forces exerted are inversely as the velocities.

That is:

$$\frac{\textit{force at } F}{\textit{force at } E} = \frac{\textit{velocity of } E}{\textit{velocity of } F}$$

or

$$\textit{force at } F = \textit{force at } E \times \frac{\textit{velocity of } E}{\textit{velocity of } F}$$

Velocity Diagram

The constructions so far shown will give the velocity relation between any two points at any selected position of the mechanism. In a shaper mechanism, for example, the complete study of the motion makes necessary the laying down of a velocity diagram in which the velocity of the cutting tool at various points is plotted vertically to scale along a horizontal line the length of which represents a complete stroke. It is necessary only to repeat the construction shown in connection with Fig. 7 for a sufficient number of positions to obtain these various velocities for the velocity diagram. These repeated constructions involve the drawing of a good many lines, but the constructions being simple repetitions of one another, these numerous lines do not lead to mental confusion if the principle is understood.

It should be noted that in many mechanisms the lines leading to the instantaneous center become parallel at certain positions and do not meet, and in other positions near this one these intersections will fall beyond the limits of the drawing board. The former case does not lead to uncertainty, as it shows that the velocity of the connected pins C and D, of Fig. 7, are identical and call for no construction. The velocity curve on each side of this point is usually quite flat and does not need closely spaced points for its determination, such points as can be found by constructions that fall within the limits of the drawing board being sufficient.

Illustrations from Common Constructions

The simple constructions shown give a complete exposition of the method, but additional illustrations are desirable for those to whom it is new.

Fig. 8 represents the common crank, connecting-rod and crosshead mechanism of a steam engine, and by the construction shown we obtain the velocity of the crosshead compared with that of the crankpin. Recalling the proviso of principle (A), we draw the vertical through the center of the crosshead pin, extend the crank and find the instantaneous center A of the connecting-rod. Letting BC represent the velocity of the crankpin, we draw AC. From A as a center and through the crosshead pin center, we draw the arc DE and find point E, which, were it a point of an arm EF of the connecting-rod, would, by principle (B), have the same velocity as the crosshead pin. Drawing EG, its length is that velocity.

Effect of Changing the Fixed Link

The remarkable transformation in the character of the motions due to fixing different links of a mechanism have already been referred to. By changing the fixed link of Fig. 8 to its connecting-rod, we obtain Fig. 9, which will be recognized as the mechanism of an oscillating steam

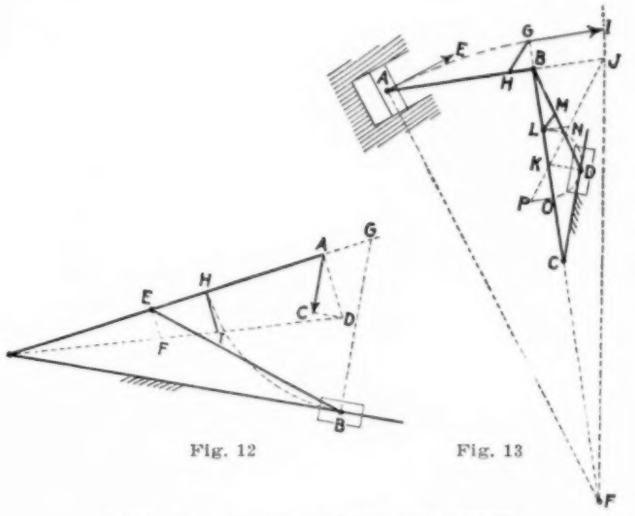


Fig. 12 Fig. 13

FIGS. 12 AND 13. FORCE RELATIONS

engine, the block at the right oscillating on its trunnions, while the inclined link slides through it. The construction for finding the velocity of this sliding link as compared with the crankpin is given in the illustration, but is so similar to the last one that detailed description seems unnecessary. The reader is advised to trace it through.

A more striking change in the character of the motion results from making the crank of Figs. 8 and 9 fixed. This construction is shown in Fig. 10, in which the former crank is AB, shown in a vertical position and fixed. A moment's consideration will show that we have here the revolving part of a Whitworth quick-return motion. The former link, here the radius arm AC, is the constant length, constant speed, first-motion radius arm of the Whitworth motion, BC, carrying the slide, being the variable-length, variable-speed radius arm and AB being the eccentricity. Adding link DE and slide E, we have the mechanism complete.

The radius arms AC and BC here revolve about fixed centers, and when comparing their velocities we have no instantaneous center to consider. Let the velocity of pin C of arm AC be represented by the line CF. The velocity of this pin in the direction perpendicular to arm BC is

CG, found by constructing the triangle CFG. The velocity of the tool-slide E is now found from CG precisely as in the case of the steam-engine mechanism of Fig. 8. We find the instantaneous center H of the connecting-rod DE, draw GH and find DI, the velocity of the crankpin D. The arc EJ drawn from H gives the point J having the same velocity as E, this velocity being JK.

Slotted-Arm Quick-Return Motion

This identification of mechanisms that are apparently radically different as essentially identical and differing only in the link selected to be fixed is one of the most remarkable results of the Reuleaux analysis. Another result of it is shown in Fig. 11, which differs from Fig. 10 only in the proportions of its parts, but which becomes the oscillating-arm quick-return motion to be found in most shaping machines.

The line AB of Fig. 10 has been lengthened and the fixed-length radius arm AC shortened and placed at the top instead of the bottom; that is, the mechanism has been turned bottom side up. The construction for the velocity of the tool-slide scarcely differs and is lettered in the same order, CF being the constant tangential velocity of the crankpin, CG its velocity perpendicular to the swinging arm and DI the velocity of pin D. The instantaneous center of the connecting-rod DE is at H, and the velocity of the tool-slide is JK.

Force Relation in the Toggle Joint

A simple illustration of a case involving the force relation is found in the common toggle joint, Fig. 12, in which a known weight is attached at A and it is desired to find the resulting thrust at B. The velocity with which the weight descends, which need not be known but is assumed as represented by any convenient length of line as AC, is resolved by the triangle ACD into tangential and horizontal components, of which the former is AD. The corresponding velocity of pin E is EF. The instantaneous center of link BE is G. The point having the same velocity as B is H, and the velocity of H and of B is HI. Now we have:

$$\frac{\textit{force at } B}{\textit{weight at } A} = \frac{\textit{velocity of } A}{\textit{velocity of } B}$$

or

$$\textit{force at } B = \textit{weight at } A \times \frac{AC}{HI}$$

Force Relation in Compressed-Air Double Toggle-Joint Riveting Machine

A more complex case of force relations is found in the double toggle joint of a compressed-air riveting machine, Fig. 13. At A is the piston pin, the cylinder and piston being indicated. Link AB joints with BC, C being fixed to the frame. Link BD connects pin B with the slide to which the rivet-closing die is attached.

The piston, as in the last case, is assumed to move at any convenient velocity represented by the line AE. Drawing AF perpendicular to AE and extending BC, we find F the instantaneous center of AB. The arc AG locates point G which were it attached to AB by the arm GH, would move with the same velocity as the piston. Laying down GI equal to AE and drawing IF and BJ, we find BJ the velocity of point B. Next, we find the instantaneous center of BD at K. The arc DL gives the point L which, were it attached to BD by an arm LM, would have the same velocity as D, and drawing LN, we have that velocity.

It should be noted that we may also find a second point O having the same velocity as D, but the velocity OP found from it is obviously equal to LN. In point of fact there are always two such points, on opposite sides of the instantaneous center. Were the arc DE of Fig. 8 extended to a complete circle, it would give a second intersection with AB beyond the instantaneous center. In Fig. 8 the second point is beyond the limits of the drawing, while in Fig. 13 it is within them, and that is all the difference there is between the two cases.

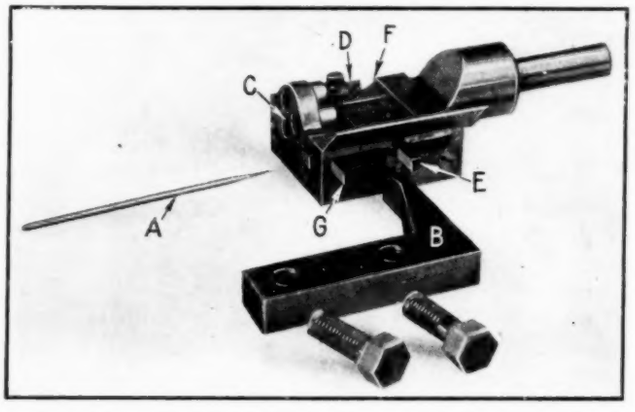
The force relation is given by the equation:

$$\textit{pressure on rivet} = \textit{pressure on piston} \times \frac{GI}{LN}$$

Special Tool for Pointing Small Steel Pins

By E. A. Thanton

An interesting tool is used in the shop of the Keyless Lock Co., Indianapolis, Ind. Pins 5 in. long, used for the familiar paper spindles, are pointed in a machine having but 2¼-in. feed. One of these pins, which is about $^{7}/_{64}$ in. in diameter, is shown at A. The point is beveled



TOOL FOR POINTING SMALL STEEL PINS

back about ½ in. In use the tool itself is carried in the turret of the machine. The piece B is bolted to the cross-slide tool block. The wire is fed in through the bushing C between guide rollers. Just back of the guide rollers is a cutting tool set into a cross-slide D.

In starting the cut the slide is set in as far as it will go, so that the tool starts to cut at the center of the wire and gradually feeds outward as the turret feeds the tool along the wire. This forms a nice even-tapered point. The cross-slide carrying the cutter is operated by means of the projection on the piece B. As the box-tool is fed forward this projection strikes the piece E and causes the cutting tool to move outward as it is forced along the bevel F. Reversal of the movement causes the projection to strike the piece G and returns the cutting tool to central position again, ready for the next cut.

In Lowering a Large Steel Storage Tank to its foundation in a deep pit Honolulu engineers built up a temporary resting place of blocks of ice and then, after the structure had been properly centered, melted the ice uniformly with steam. The reservoir is 24 ft. in diameter, 25 ft. high, weighs 14 tons, and has a capacity of 80,000 gal.

Indicating Gages with Single and Double Levers

EDITORIAL CORRESPONDENCE

SYNOPSIS—This shows a variety of applications of the multiplying-lever form of indicating gage, some of which are very ingenious and interesting. They are used to test shoulders and recesses which seem to be gaged in this way more easily than any other. They are not difficult to make in any toolroom, the construction being clearly shown in every case. Their increasing use by the Denver Rock Drill and Machinery Co. for a number of years is a good indication of their usefulness in maintaining accurate work.

Compressed air is very thin stuff and gets through decidedly small openings when it has the chance. For this reason makers of pneumatic hammers and similar appliances require careful gaging methods to insure proper fits and the duplication of parts. Those who remember the gages previously shown from the shops of the Denver Rock Drill and Machinery Co., Denver, Colo., will be glad to see how this work has been extended.

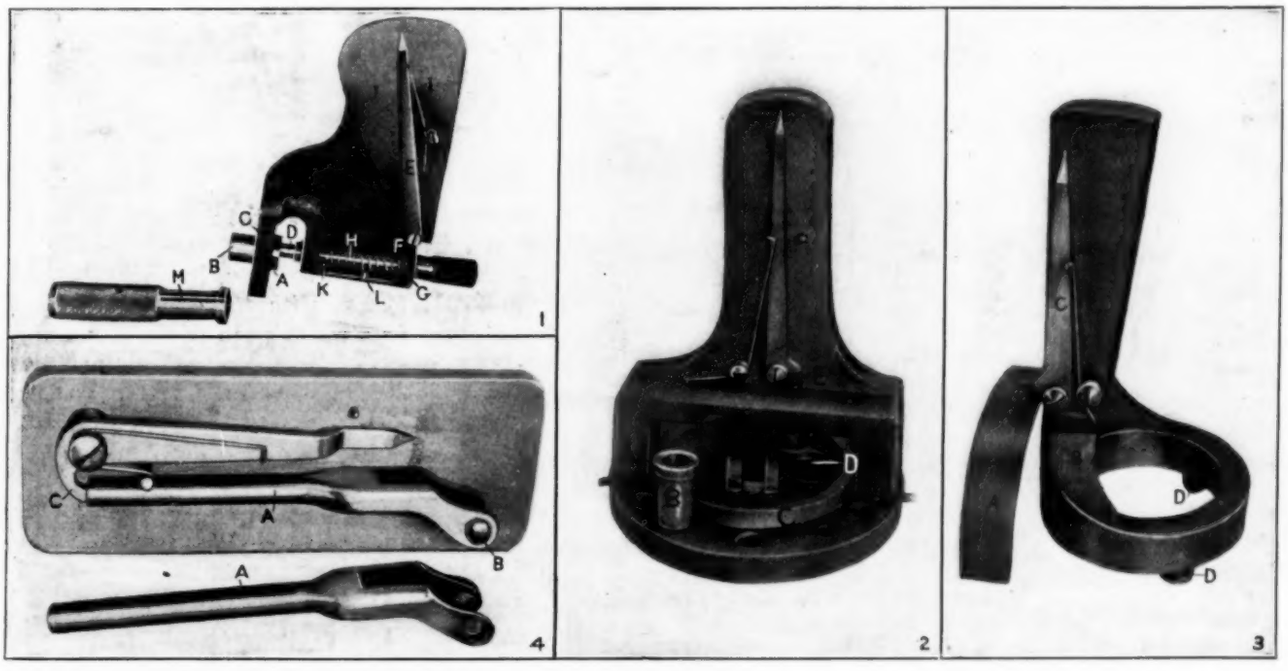


FIG. 1. INDICATING THICKNESS OF FLANGE
FIG. 4. MEASURING A SMALL LEVER

FIG. 2. INDICATOR FOR DEPTH OF COUNTERBORE

FIG. 3. TESTING A HALF-RING

The multiplying-lever principle is used almost exclusively, and the varied applications of it make an interesting study. Fig. 1 shows its application to the gaging of the thickness of the flange *A* on the nipple *B* and also the depth of the counterbore which it fits into. This nipple is slipped into a side opening of the foot *C* and gaged through the plunger *D* and the lever *E*. The lower end of the lever goes through the barrel of the gage *F* and makes contact with the flange *G*. The spring *H* tends to force down the plunger and the spring *I* tends to keep the needle against the pin *J*.

To use, the plunger is pulled back by the knurled end, and the pin *K* locked in the slot *L*. Then the nipple is put into place, the plunger released by turning the knurled end and the thickness of the flange read by the end of the pointer. The accuracy of the reading is tested by the standard test piece *M*, which is of steel, hardened and ground.

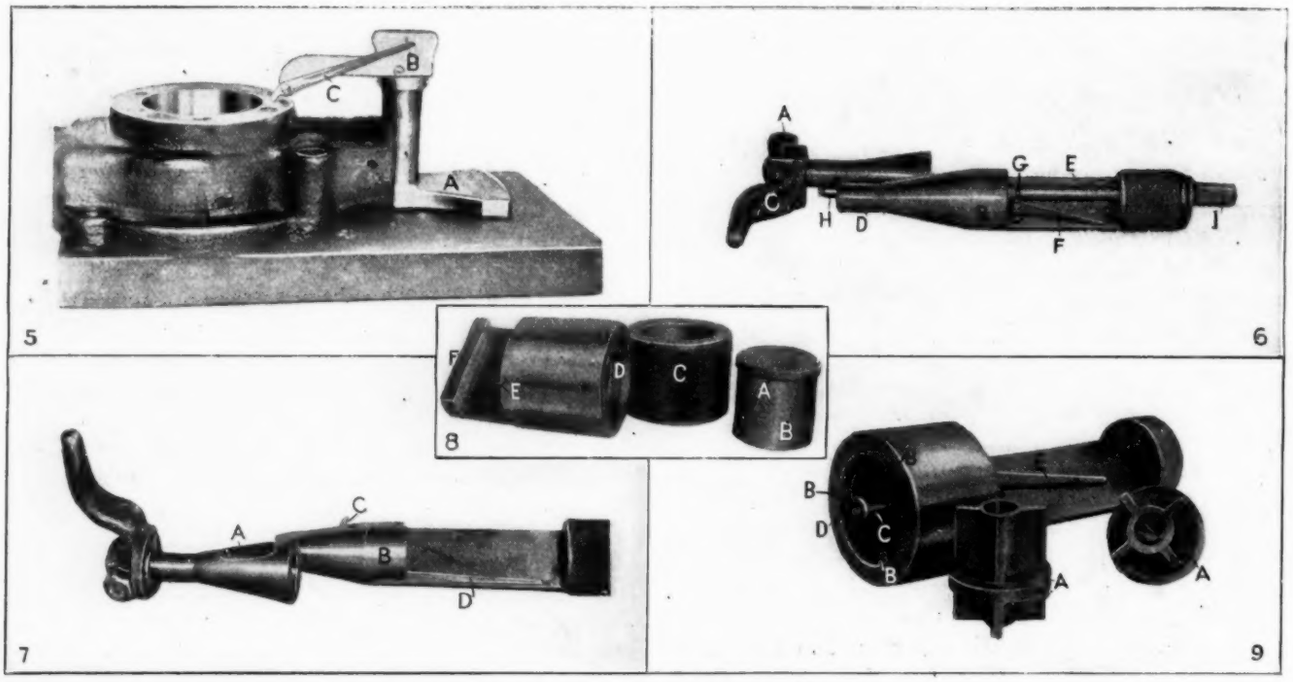
This nipple fits into the head *C*, Fig. 2, at the counterbored hole *D*, while the lower end of the plunger *E* goes against the shoulder of the counterbore when the gage is placed to straddle the head as shown. Letters *A* and *B* refer as before to the nipple.

Another somewhat similar gage is shown in Fig. 3, the object being to gage the height of the half-rings *A*. These are placed on a surface plate so that the projection on the pointer *C* makes contact with the ring, the gage feet *D* resting on the surface plate. The upper end of the gage *E* serves for a handle as well as for the graduations for the pointer readings.

GAGING DISTANCES FROM PIN HOLE

Another very particular piece is the forked lever *A*, Fig. 4, the special measurement being from the hole in the forked end to the extreme end of the lever. This is gaged by placing the hole in the lever over the pin *B* and letting the curved end of the indicating lever contact with the end, as at *C*. The other end of the lever indicates the variation, only 0.005 in. plus or minus being allowable.

The device shown in Fig. 5 is in reality simply a surface gage with a multiplying-lever attachment. The standard *A* is very substantial and mounted on three



FIGS. 5 TO 9. VARIOUS FORMS OF INDICATING GAGES

hardened feet. At the top of the post is an arm *B* carrying a pointer *C* which multiplies ten times at the outer end. This is used while the piece is in the lathe, the faceplate serving as a surface plate, and also for final inspection on a surface plate as shown.

Gaging Depth of Taper Holes

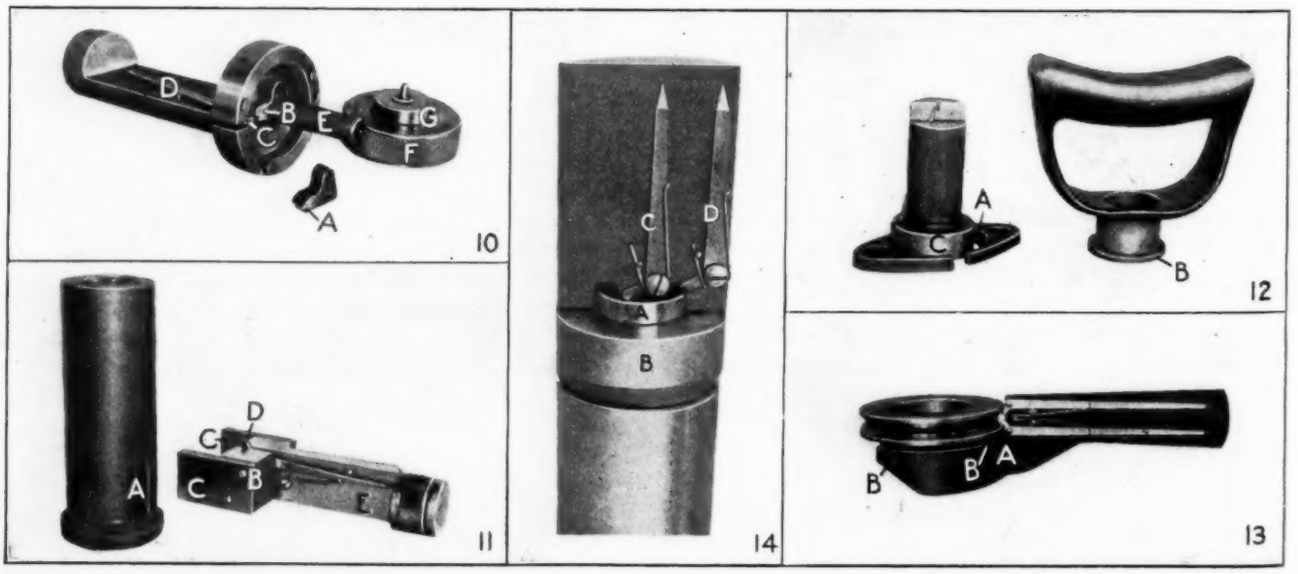
Gaging the depth of taper holes so that a taper plug will go in the correct distance is not an easy proposition. But the gages shown in Figs. 6 and 7 handle both the fit of the plug and the location of a slot through the plug.

The plugs are made to gage the cross-holes drilled in the end for the bolt *A*, Fig. 6, so that they can be made and assembled in quantity. The gage *B* is used in the hole to insure the taper being at the right depth so the plug will be tight when the lever *C* just bottoms on the outside of the casting.

The body of the gage is turned to the correct size and taper for the hole, including the smaller end *D*. The rod *E* runs through the gage lengthwise, showing at the cut-away portion, which affords a place for the indicating needle *F*. The short end of this lever fits into the groove *G*, which allows the rod *E* to be turned completely around.

Only partial turning is necessary, however, the hook *H* being turned into line with the small end by the knurled end of the rod *I* in order to be pushed through the opening for the plug. Then the rod is turned until the hook contacts with the outer surface and the depth of the hole read by the pointer on the flattened portion of the body.

In addition to gaging the depth of the hole, the position of the slot in the body, which corresponds to the slot *A* in the plug, must be accurately located, Fig. 7. For this purpose the gage *B* is used, the taper portion



FIGS. 10 TO 14. A NUMBER OF OTHER FORMS OF INDICATING GAGES

fitting the hole and the hook C on the multiplying lever D making contact with the upper end of the slot in the body.

Gaging Shoulders and Depths

Another shoulder, or flange, gage is shown in Fig. 8, this being for gaging the flange A of the bushing, or sleeve, B. To measure this accurately, the bushing is slipped into the knurled ring C and the projecting collar A pushed into the ends of the gage until the ring C contacts with the end of the gage. In this way the flange A is forced against the short end of the lever D and the multiplied reading taken off at E. The raised edge F protects the needle from injury.

A somewhat different gage is shown in Fig. 9, this being for measuring the depth of the hole in the valve with reference to the seat. The valve seat A rests

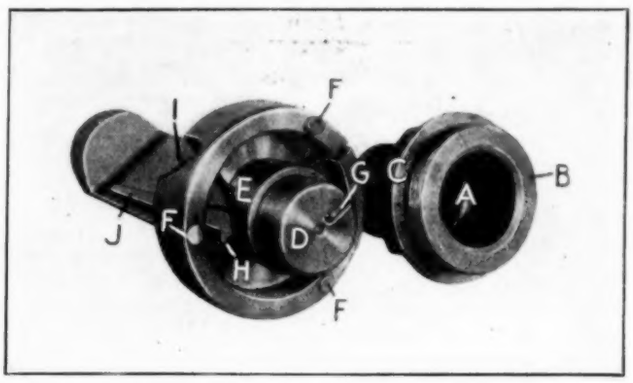


FIG. 15. GAGING RELATION OF RECESS AND OUTER FLANGE

against the three spots B, the metal between being relieved for this purpose. The hole in the valve fits over the projection C, while the plunger D, connected with the short end of the lever E, indicates the relation between the bottom of the hole and the face of the seat.

The gage shown in Fig. 10 is for the distance from the lower hole to the lip A in the pawl shown in the foreground. This is shown in position in the gage at B, with the lip in contact with the short end of the lever C, the long, or needle, end being at D. The pawl is held in position by the plug E. The gage is also used to test the piece as it is being ground, the pin on which the trigger is held fitting into the central hole of the gage, instead of the pin shown. Three hardened plugs act as feet to set it square against the face-plate.

The piece F is a standard for testing the gage at regular intervals. The central pin fits the hole in the gage already referred to, the raised edge G representing the distance to the lip of the pawl.

Gaging Flats and Flanges

The use of the multiplying lever in gaging the depth of flats on a cylindrical piece is shown in Fig. 11, the flat being at A. The gage is pushed over the piece until the base B seats on the flat, being guided by the side pieces C. The short arm of the lever D contacts with the cylindrical portion of the piece and moves E to show whether or not the flat is the proper depth.

In Fig. 12 another application gives the depth of the recess A, in the flange, this recess fitting around the flange B of the handle at the right. Its purpose is to hold the handle without shake and yet allow it to turn readily with the hand.

The end of the gage C fits into the recess in the flange and the pointer indicates the depth at its upper end.

Double-Needle Gages

The use of two needles, or arms, on a single gage is shown in Figs. 13, 14 and 15. The first is for gaging the ball race shown, the two levers indicating not only the diameter or radius of the sides of the race, but their relation to each other and to the side of the race.

The gage consists of the substantial casting A, carrying the hardened-steel pins B on which the ball race rests. Pushing the race into contact with a stop at the small end of the levers brings them into contact with the sides of the race and indicates the size at the long end.

To measure the length of the neck A, Fig. 14, as well as the depth of a counterbore in the center, two levers are used as shown. The base of the gage is bored to fit the neck of the shaft, as at B, this bringing the lever C into contact with the counterbored surface and the lever D with the end of the neck. The tolerances are 0.010 in. for the first and 0.020 in. for the second.

The third of these gages the surfaces A and B with relation to the flange C. The end of the gage D fits into the smaller hole of the piece; the gage E fits the larger hole at the end, and the hardened pins F seat against the flange C. The smaller lever G makes contact with the shoulder A, while the lever H gages the surface B, both indications being read from the pointers I and J.

As can be seen, this form of gage, with suitable modifications which can be made by any ingenious toolmaker, lends itself to many uses and makes a very reliable indicator. When standard gaging pieces are made for testing such gages, any error due to the pointers becoming bent can be readily discovered and corrected. They can be used quite rapidly and have proved so successful in maintaining the accuracy required on air-tool and meter work that they deserve careful consideration by all tool designers.

Inspection of War Material

By Tecumseh Swift

The events of these days are to me provocative of reminiscences of the times of the Civil War. It is known well enough by everybody that many establishments in the United States are now busily employed in the manufacture of various war material, and in connection with such manufacture we are hearing interesting stories about the peculiar insistencies of some of the inspectors who have to examine and pass on the output before shipment.

This is not at all new to me. It happened, now more than fifty years ago, that I was employed on war material almost throughout the entire period of the Civil War in one of the largest machine shops in the state outside of New York City (which then boasted a number of large marine-engine works, which, as, for instance, the Novelty Works, did a wide variety of other work), and in this shop I consequently had my experiences. Our work in this shop at the beginning of the war was in the way of assisting in the manufacturing operations of the Watervliet Arsenal. The work at this arsenal in the ante-bellum

days had been the manufacture of harness and horse equipment, and naturally the activities there at the beginning of the war were continued in the same line. The work that came to us first, then, was the making of bits for artillery horses, and later also for cavalry. The sides of these bits were drop-forgings, and they were to be filed all over previous to tinning. The filing of these bit-sides employed a great many men, both at the arsenal and at our shop. Our work was on a piecework basis, while the men at the arsenal worked strictly by the day. It was not long before it became known to all of us that while we were filing on the average twenty-five sides each per day, and not earning extravagant wages at that, the men in the arsenal were filing only two sides per day, with a general understanding that if anyone should file three in a day he would be in danger of being discharged for slighting his work. That was the scientific management of the period.

This arrangement came to an end after a time. The inspector of the sides at our shop was an old and superannuated regular army sergeant, absolutely honest, I believe, but with unlimited capacity for finding fault, and as there were no gages or standards to refer this work to, it all depended upon his judgment, of which he had plenty—such as it was.

Inspecting Bit Sides

I was sent one day to assist him by stamping the sides with his mark as fast as he examined them. He would hand them to me, frequently with some remark as to the file streaks not all running the same way, or something of that sort, and I would stamp them all as fast as I received them. It turned out after a time that whenever he had made a remark to me it was meant as a rejection of the piece, and when he "caught on" to what I had been doing the inspection came to an end at once. He told his story to the arsenal authorities and then a new arrangement was made. After that our filing was all done by day work, with never a hint allowed with reference to hurrying up on the job, and the shop proprietors were paid a liberal percentage upon all the wages. Of course not half as much work was done, and none of it was done any better, but it all passed, as there was then a different inspector.

Then we got into the making of shot and shell—all cast iron, 2-in. solid shot, 24-pounder, 32-pounder, 8-in., 10-in., 13-in. and 15-in. shell. The 13-in. and the 15-in. shells, we understood, were to be used for battering fortifications, and were not considered to have the function of regular explosive shell. They had a central spherical cavity about 4-in. diameter, and the charge of powder they carried was only for the purpose of destroying the shot, so that it could not be picked up and thrown back at us.

The smaller shells had a reamed taper hole for a brass fuse plug, while the larger shells were tapped for a large, flat, white-metal time fuse to be screwed in. Advantage was taken of the latter circumstance for a little experiment. One of the 13-in. shells was filled with water, a steel, tight-fitting plug was screwed down on to the water and the shell was rolled out into the yard and forgotten. One morning in January when we came to work there lay the shell split entirely in two by the frost, the halves lying apart and not even touching each other. A 15-in. shell served the same way did not split.

The making of those shells was fine work for those days, and would pass for first-class work even now. I had the turning of the iron patterns for the smaller sizes of the shells, and it was then that I first learned to work to thousandths of an inch. Of course I had a revolving rest to give the spherical shape.

The skill requirements were quite as exacting, although entirely different, in the foundry as on the pattern work in the machine shop, and the shells as turned out were a product not to be ashamed of.

Inspecting Shot and Shell

When it came to the matter of inspection there were many requirements to be satisfied. To begin with, the iron to be used was strictly specified and closely tested by sample. Then the shells of each size were required to be within certain narrow weight limits, and must not have any discoverable sand-holes in the side opposite the fuse, which was the top side in the mold. They must pass through and not pass through ring gages tried in every direction, the difference, I think, for the 24-pounder and the 32-pounder shell, of which we made the most, being 0.04 in. This for castings as they came from the mold. The core was required to be central in the shell, and for this there were special calipers made to reach inside the shell and measure the thickness of the sides all around. The tapered or threaded holes for the fuses had also their limit gages to be satisfied.

Although some of these requirements were of vital importance, and all of them justified from the military viewpoint, the official inspection at the works before shipment was more or less a farce. The inspectors in this case were not military men at all, but a couple of rough mechanics of the cheaper class, apparently not used to anything fine or exacting in all their experience. They came to the works about 9 o'clock and left about 4. When they came in the morning they were first shown into a private room upstairs in the office, and they visited this room again for another quarter of an hour before leaving. All the inspection they were ever seen to do was to try the ring gages over a few of the shells and to peck the outsides with a sharp-pointed hammer, and they passed practically everything.

There is nothing, after all, so bad about this story as the telling of it might suggest. The proprietors of the works were stanchly patriotic, and they were as honest and honorable as any men I have ever known in my life. The strictest care and watchfulness were maintained all through the processes of production, and everything was inspected as it went along, so that any proper official inspection afterward would have been, as to all essentials, a work of supererogation in any case.

An Incident of Spanish War Days

During the Spanish War I one day passed through an establishment, now out of business, where rifle projectiles 4 or 5 in. diameter were being turned out, and there I incidentally noticed a curious thing. A man was going over a lot of projectiles and trying threaded gage plugs into the tapped holes in the base or rear. There were of course two plugs, one to go in and the other not to go in. It appeared that the holes were tapped, say a millionth of an inch, more or less, too large, so that both of the plugs would go in, and the man was carefully, and I must say skillfully, battering the threads of the hole a little so that the "not go in" plug should not go in. I could not imagine such an incident occurring in our old shop.

Measuring Temperatures for Heat Treatment Processes

By F. G. Coburn*

SYNOPSIS—A discussion of actual experiences, including some of the elementary information which is generally overlooked; the construction of thermocouples, how they operate and why they frequently give unsatisfactory results.

This is not intended to be a treatise, but rather a discussion of the ways and means of heat treatment—not so much an original contribution to the subject as a compilation of information as to the details of equipment and methods of using it. This information is so elementary that most books on the subject pass over it, and thus leave each investigator go through the trials and tribulations of finding out what means and methods to use in developing heat treatment.

The importance of proper equipment cannot be overestimated. Proper equipment is not necessarily the most expensive. In fact, in the long run, not infrequently it is the cheapest, even in first cost. I remember purchasing a thermocouple a few years ago for use in a furnace where temperatures were frequently changing. It was delivered with a graphite sheath, which should not have been furnished, because it is so thick and such a poor conductor of heat that its temperature changes slowly; hence the temperature registered by the thermocouple was always out of phase with the temperature of the furnace. And no matter how good the thermocouple and its galvanometer were, no matter how much they cost, the equipment was not giving the furnace temperature, which was the purpose for which it was acquired.

Knowing the Equipment

Poor equipment—that is, decidedly unsuited equipment—may be made to answer in a pinch, provided the user has a thorough knowledge of it, including a knowledge of its limitations. Knowledge of one's equipment is certainly essential, for with the best equipment and no knowledge of its limitations the most puzzling and frequently misleading results will be obtained.

For example: I remember my first experience with a portable pyrometer, consisting of a thermocouple and galvanometer, concerning which the manufacturers gave no information whatever, and I doubt whether the manufacturers at that time had much knowledge themselves regarding it. At any rate, the discordant results obtained forced its early abandonment.

I also recall the case of the use of a portable pyrometer in a certain forge shop, where I saw the foreman, with a piece of steel in the furnace, the door closed down, the thermocouple inserted at the corner of the door, looking with great interest at the needle of the galvanometer. When the needle reached the temperature he thought was about right, he pulled out the thermocouple and allowed the steel to cool in the furnace. The cold junction end of the thermocouple was so hot that it was necessary to wear a glove when pulling out the thermocouple, and handle it very smartly, at that. That cold end temperature was probably not less than 200 deg. F.; what it actually was no one knew. But the reading of the galvanometer gave no real indication as to the temperature at the point where the thermocouple was inserted, and there was no information even so good as the reading of the galvanometer as to the temperature of the metal itself.

Still another example—that of a large annealing furnace, about 5x30 ft., which contained three thermocouples connected to a recording pyrometer. These thermocouples were short, so that the ends barely projected into the furnace. No attention was paid to the temperature of the cold junctions. The recording pyrometer was mounted on the side of the furnace, where it was subjected on the one hand to the heat coming from the furnace and on the other to drafts of air, and altogether the equipment was admirably designed to give false and misleading information as to the furnace temperature, and again no means was provided for obtaining the temperature of the metal.

A Little Thing

A rather interesting case of disregard of the cold end temperature came to my attention not long ago. A tool manufacturer reported to the firm from which he bought his thermocouples and pyrometers that he had no uniformity of results from their heat treatment. He had not tampered with the galvanometer, he had his thermocouples tested at a good laboratory, and when there was no improvement in their work he inserted new thermocouples, still with no change for the better. Fortunately for that company, the thermocouple manufacturer had an observant person to send to look at the job. He found that the cold ends were close to the window, with the result that changes in temperature, even between bright days and cloudy days, would exert a very marked effect on the galvanometer readings. He caused them to bury the cold junctions, recalibrated the pyrometer for the new condition, and thereafter no difficulty appeared.

More examples are unnecessary, but I must repeat that a knowledge of the limitations of pyrometric equipment is essential if satisfactory results are to be secured.

It is particularly necessary to know the degree of accuracy attainable with the equipment and desirable for the work in hand. Temperature is always a most difficult element of calculation to measure. Any engineer who has had experience with engine tests knows that; and any difficulty had in the ordinary range of the mercurial thermometer is very much magnified when dealing with temperatures in the range of the thermocouple.

The maximum accuracy ordinarily attainable in shop practice is about 10 deg. C., or say 18 deg. F. By this it is meant that if the thermocouple itself is properly calibrated, that the galvanometer, if it is used, has been calibrated with the thermocouple and its connecting leads; that the cold end is maintained constantly at the temperature at which the equipment was first calibrated; and if a few other important factors are controlled, any tem-

*Naval constructor, United States Navy.

perature registered by the pyrometer is probably within 18 deg. F. of the actual temperature at the hot end of the thermocouple. Further, it means that if a critical point of a steel is determined, the temperature to which the forging itself is brought for heat treatment must be at least 36 deg. F. higher than the critical point thus determined, in order to allow for a possible minus error on the part of the couple with which the critical-point determination was made and for a positive error on the part of the thermocouple with which the temperature of the forging was measured. This matter of precision is not very frequently taken into account.

It may be that the greatest obtainable accuracy is desired, in which case the problem is not at all simple, and for which the greatest care and most constant vigilance must be exercised to maintain the equipment at maximum accuracy. It will pay to do a certain amount of experimental work to find out within what limits the heat-treatment temperature may be allowed, because it may be found that these limits are fairly wide, and that the accuracy required of the equipment is correspondingly less. This, in turn, will result in cheaper equipment to buy and less difficulty in maintenance.

It must be apparent from the foregoing that definite, accurate knowledge of the limitations of one's pyrometric equipment must be known.

The Method for High Temperatures

Pyrometry may be defined as the art of measuring temperatures above the limit of the mercurial thermometer. It may be interesting to review for a moment the method which was used in determining some of the high temperatures which we consider we know.

Since temperature is not an actual bit of matter that can be weighed or similarly measured, it it necessary to determine temperature by observing some natural phenomenon, such as the expansion of a liquid or a gas which occurs when this substance is maintained at the temperature which it is desired to measure. The Centigrade scale is determined, for example, by noting the length of a column of mercury inserted in melting ice, and again when it is inserted in the vapor immediately above boiling water. The difference in length is then divided into 100 divisions, or degrees, and calling the melting point of ice 0 deg., and the boiling point of water 100 deg., then any intermediate temperature is given by the length of the column of mercury when maintained at that temperature, this length being expressed in degrees. The scale may be extended above the boiling point of water and below the melting point of ice, and temperatures without the range obtained by extrapolation. This is an elementary explanation, and takes no account of various factors essential in a scientific determination, but it will suffice as an illustration.

The temperature of iron when it is hot enough to weld would, of course, melt the glass and vaporize the mercury of a mercurial thermometer; so it becomes necessary to find some other means of measuring the temperature. It is a bit difficult at first to see how the original investigators determined such high temperatures as the melting point of copper, for example.

It was done by observing the expansion of gases at different temperatures. Suppose that a body of gas is confined in a small receptacle and maintained at constant pressure, but allowed to expand, as in a manometer or ordinary mercury pressure gage, the container for the gas being of a higher melting point than that of the substance the melting point of which is to be determined. Then, if the volume is determined at the melting point of ice, and again at the boiling point of water, and the difference in length divided into 100 parts, we have the increase in length for each degree Centigrade of temperature. Then, if the length of the column is determined at the melting point of copper, and we measure its increase in length from its length at the melting point of ice, we have the number of degrees Centigrade at which the copper melted. The scale of temperatures thus determined is what is referred to as the "gas scale."

Natural Law of Metals

Long ago it was discovered that between different metals or different alloys of the same metal there was a peculiar thermo-electric phenomenon; that is, if two wires of dissimilar metals were coupled together, one junction kept cool and the other heated, electro-motive force was generated at the hot junction, this electro-motive force being nearly proportional to the difference in temperature. The ordinary thermocouple is simply the practical application of this law. No electro-motive force is generated when both ends are at the same temperature.

If the cold junction is maintained at 0 deg. C. and the hot end maintained at some high temperature—say that of melting copper—the electro-motive force generated would be a positive quantity and measurable with a millivoltmeter—that is, a voltmeter graduated to read in thousandths of a volt instead of volts. Thus a scale might be set up which could be called the "thermocouple scale," and which would do for all thermocouples made of wires exactly the same in every respect as the wires used in this thermocouple. Such temperatures would not be comparable with temperatures given by other thermocouples; so it is further necessary to revert to the gas scale for measurement.

It is the practice to determine the millivoltage of a thermocouple at various known temperatures of the hot junction, the cold junction being maintained at 0 deg. C. Then by plotting a curve, with known temperatures as abscissas and millivolts as ordinates, any millivoltage of that couple may be transformed into degrees by reference to the curve.

The ordinary pyrometer consists of a thermocouple and a galvanometer to read the electro-motive force generated by the hot junction. The pyrometer is graduated in degrees of temperature, so that it may be read directly, without reference to such a curve; but the graduations on the pyrometer were arrived at by such reference.

A gas thermometer is not at all practical for shop use, or even for laboratory use, except by expert physicists. The thermocouple, however, is a very handy instrument, and that is why it is used. The pyrometer, or galvanometer (which, as stated above, is nothing but a millivolt meter graduated in temperatures instead of millivolts), is likewise a very handy instrument, and so the combination is practicable.

The thermocouple may be made of any two thermo-electrically dissimilar wires; but of course they must be wires that are not affected deleteriously by the temperatures to which they are raised, nor by the materials into which they are inserted. The choice of metals is dependent, basically, on whether the temperatures to be

measured are extremely high or relatively low, and also by the cost of the wires themselves.

For high temperatures—that is to say, up to 2700 deg. F.—it is necessary to use metals with a very high melting point, and there are only two kinds of couples that are really suitable; one a combination of a pure platinum wire with an alloy of platinum and rhodium, the other a pure platinum wire in combination with an alloy of platinum and iridium. The latter is rather expensive, and quickly becomes brittle; and it has been found by experience that the platinum and platinum-rhodium couple is the most suitable. As a matter of fact, it is the best couple, probably, for any temperature, but it is so expensive that for temperatures within their practical range it is better to use base-metal couples.

There is a considerable number of base-metal combinations, such as copper and constantan wires, iron and constantan wires, iron and nickel, etc. Of these base-metal combinations, several are satisfactory. My own observation has indicated that the combination of iron and constantan is the best, and my experience is that it is quite satisfactory for shop work, provided it is not worked at temperatures greater than about 1800 deg. F., or possibly 2000 deg. F. This constantan is composed of 60 per cent. copper and 40 per cent. nickel.

It has been stated that the temperature of the cold end is quite important. In laboratory work it is customary to maintain the temperature of the cold ends at any known and constant temperature, preferably that of melting ice, or 0 deg. C., which is easily done; but in the shop this is impracticable. Sometimes, therefore, the cold junction is buried underground. This, however, is rather expensive if the couple is made of rare metals, because the wires must be quite long. It is also common to find that the pyrometer—which is really the combination of the thermocouple and the galvanometer—and its connections are calibrated for some such temperature as 80 deg., which is assumed to be the average temperature at which the equipment will be used, and it is then further assumed that at no time will the cold end temperature depart materially from that figure. This approximation is a good one to make, provided it secures the desired accuracy in the work.

It is better, however, to measure the cold end temperature, and an easy way to do this is to use wires for the lead wires from the couple itself to the galvanometer of the same metals as the thermocouple. This actually transfers the cold junction to the measuring instrument, at which point the cold junction temperature may be recorded from an ordinary mercurial thermometer and allowance made for it. If this is to be done, it is necessary that the wires be pretty cheap, and this condition is satisfactorily met by the iron and constantan couple.

The user of thermocouples should, therefore, be particular to know what his thermocouples are made of, and what his cold junction temperature actually is, and should, if practicable, arrange to provide lead wires from the couple to the galvanometer of the same metals as the thermocouple itself; and then should record the cold end temperature and make allowance for it. The makers of the thermocouple will provide the user with a curve or table showing the deduction to be made from the galvanometer reading for any room temperature. Furthermore, the galvanometer should be located in a place where its temperature will be as nearly constant as is possible, in order to avoid errors in the galvanometer itself due to changes in its temperature. If these precautions are observed, and if, after the installation has once been carefully calibrated, the thermocouples are regularly checked by methods to be described later, the ordinary pyrometer installation should prove satisfactory for average work.

Some Methods Used When Making Driers

The Philadelphia Textile Machinery Co., Philadelphia, Penn., manufactures driers for various purposes. Some of the methods in use are here shown.

When drilling atomizer nozzles for tobacco driers the method illustrated in Fig. 1 is employed. The casting is located and held in the jig *A*, and a $\frac{3}{16}$-in. hole is drilled at *B*. The part is then center-punched on the boss *C*, being placed on a center plug as shown. A $\frac{1}{8}$-in. hole is next drilled at *D*. The casting is then placed on the plug *E*, and a $\frac{1}{8}$-in. hole is drilled at *F*. For the last setting the casting is located on a center plug which rests in the hole machined at the second setting, and a $\frac{1}{16}$-in. hole is drilled at *G*.

The part is thus drilled in four settings, the time required being 1½ minutes. Two of the machined nozzles may be seen laying on the table in this illustration.

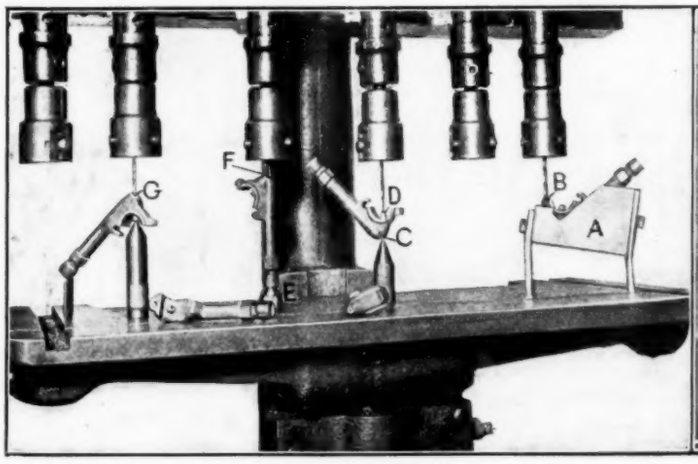


FIG. 1. DRILLING ATOMIZER NOZZLES

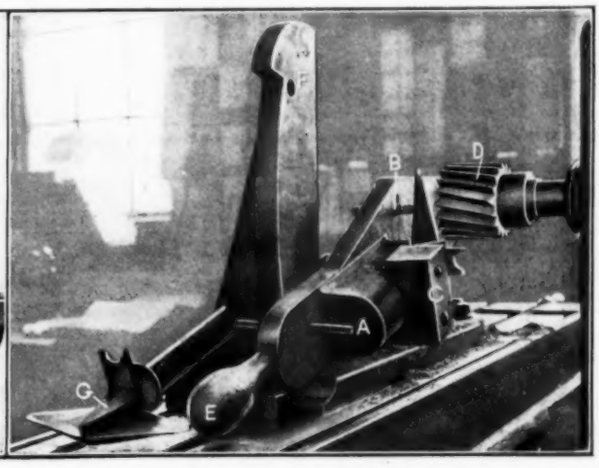


FIG. 2. MILLING BOARD HOLDERS

The fixture used when milling the board holders used on hosiery-drying machines is shown in Fig. 2. The casting is previously machined on the shank, which is placed into a hole *A* in the fixture. Two adjustable screws, as *B*, locate the piece, and a clamp *C* when tightened by means of the screws shown holds it securely. The fixture is then placed in the position shown, being

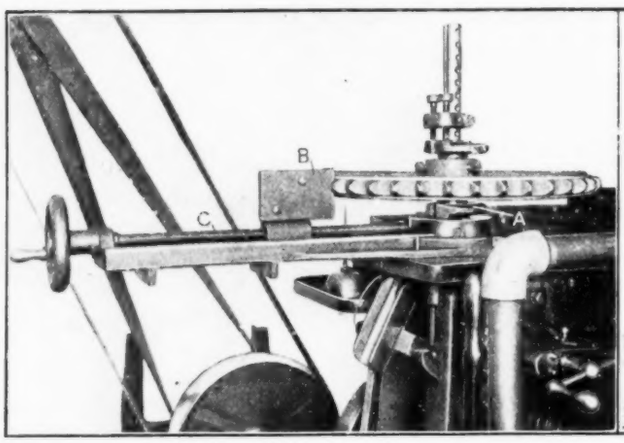


FIG. 3. MACHINING KEYWAYS IN SPROCKETS

located with an index pin, and the cutter *D* is run across the face, thus machining it. The sub-base of the fixture is next raised by means of the handle *E* and located with a pin in the hole *F*. The machining operation is then repeated. One of the machined parts may be observed at *G*.

The fixture used when cutting keyways in sprockets is shown in Fig. 3. It is important that the keyway be in line with the center of a tooth, and to obtain this result the fixture was designed.

machine are formed on an Ohl press. The steel bar is fed into the slot and placed at an angle between the punch and die at *A*, Fig. 4.

These cams are approximately 15 ft. in length and are made from 2x⅜ in. thick cold-rolled steel. The operation is done with the bar unheated, the time being 7 min.

The fixture used when babbitting gear brackets is

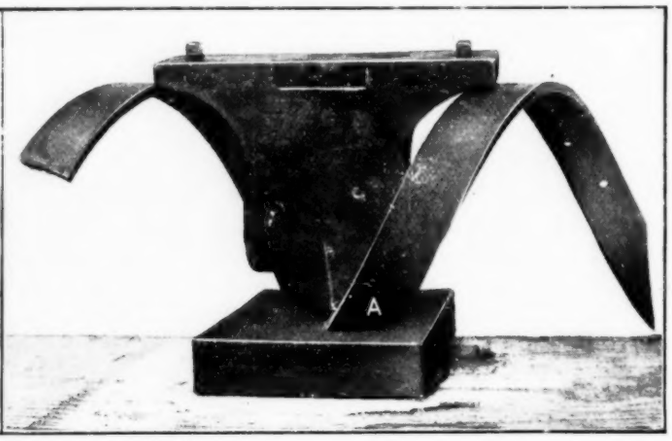


FIG. 4. FORMING CONVEYOR CAMS

shown in Fig. 5. The casting is placed in the fixture, being located by the arbor *A* and the two half-circular arbors *B*. The screws *C* are then tightened, forcing the casting against the stops so that the thickness of metal poured will be equal in the bearings.

The collars *D* are fastened on the half-arbors and an asbestos joint is made between them and the ends of the casting. Another collar and joint are held in the correct location on the vertical arbor by means of the spring *E*. Diagonal holes are drilled in the casting at *F*, and

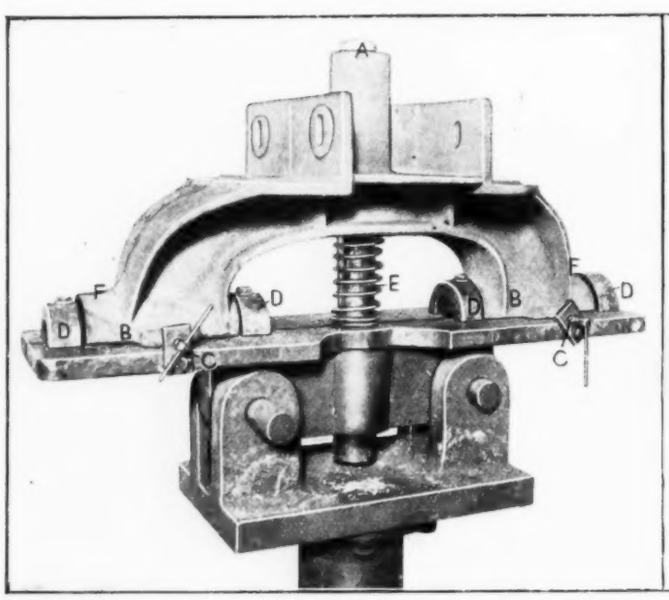


FIG. 5. BABBITTING GEAR BRACKETS

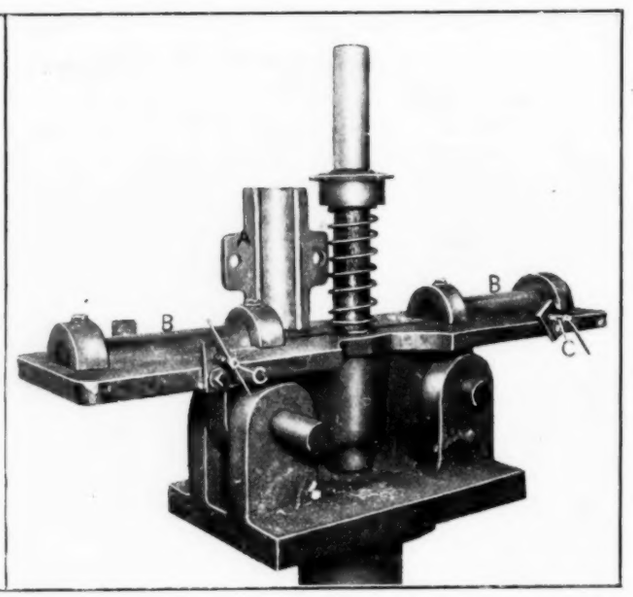


FIG. 6. BABBITTING THE CAPS

The center bore of the sprocket is placed over a plug *A*, and the V-shaped block *B* is screwed on the end of one of the teeth. The screw *C* is of sufficient length to enable the various diameters of sprockets to be keyseated. The V-block is also made separate so that others may be substituted to suit other pitches of teeth.

The ribbon-conveyor cams used on the hosiery-drying

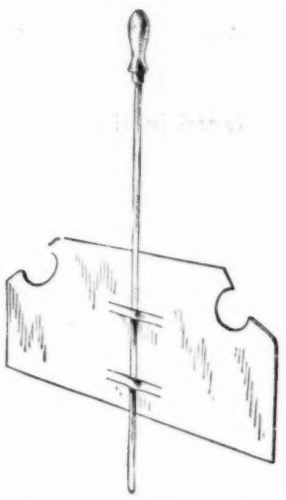
the molten metal is poured through them and also around the arbor *A*.

A view of the fixture with the bracket casting removed is shown in Fig. 6. It is also used for babbitting the caps used on the gear brackets, one of which may be seen at *A*. The caps are located in the fixture by means of the arbors *B* and the screws *C*.

Letters from Practical Men

Machinist's Depth Gage

Some time about 1912, at the shops of the Becton Dickinson Co., Rutherford, N. J., I had occasion to look after some automatic screw-machine work, the products of



A MACHINIST'S DEPTH GAGE

which were small brass parts such as needle hubs for use on doctors' hypodermic syringes, requiring small holes drilling No. 60 and smaller. The depth gage shown in the illustration was used on this work. It is made of No. 60 drill rod and has a small handle soldered on the end The shield, or slide, is of hard brass, B. & S. 26 gage, sheared in two places and formed over the drill rod.

GEORGE F. KUHNE.

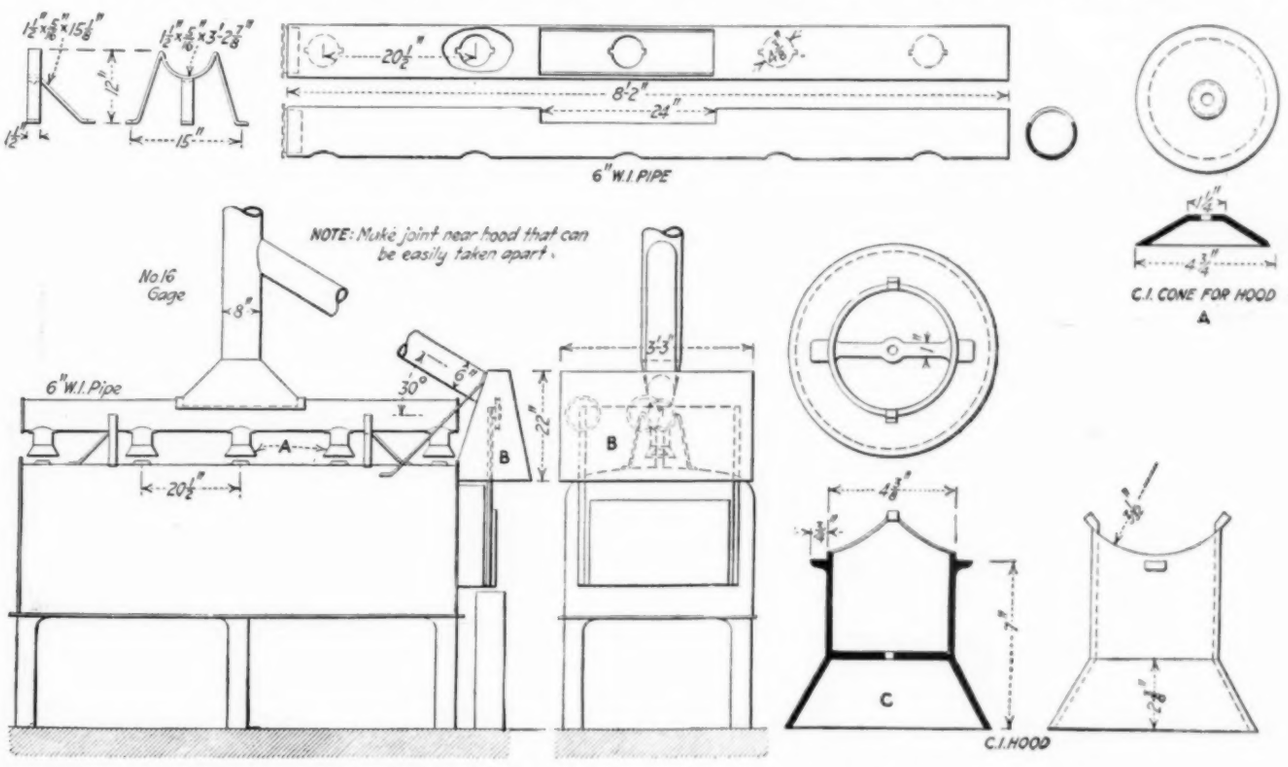
East Rutherford, N. J.

Exhaust Hoods for Heat-Treating Furnace

The illustration shows an ideal way of taking care of the poisonous fumes from heat-treating furnaces. These fumes are generally CO gas, which has a rather peculiar effect on the constitution, causing sickness and heaviness and making the men logy about their work. We have had many cases where men have been obliged to remain at home for several days to recuperate from the effect of this poisonous gas.

This exhaust system is quite different from the ordinary systems installed in connection with heat-treating furnaces. The usual method is to place a large hood over the entire furnace and rely on this to carry off the fumes. This method of using the large hood has many objectionable features that are overcome by the arrangement shown. The draft is rarely sufficient to carry off all the fumes, and the hood often interferes with the workmen by shutting out light and being in the way of cranes.

Notice particularly the small cone *A*. This is placed inside of the small hood and fastened by an ordinary bolt and nut. It can be easily raised and lowered so that the draft in the pipe may be properly regulated. When



UNUSUAL ARRANGEMENT OF EXHAUST HOODS FOR HEAT-TREATING FURNACES

this cone is in place, the small opening around the outside makes it possible to get an exceedingly strong draft just where it is most needed. The large hood *B* in front should also be noted. This takes care of the fumes when the furnace door is open.

Other types of hoods have failed for this class of work, but we have found that this particular arrangement of hood and cone works out very satisfactorily, both from an efficiency standpoint, and in considering the men's health and general working conditions.

We found it best to make both the cone and the small hood *C* of cast iron instead of sheet metal, as the former will stand the heat better, will not rust and has many other valuable qualities. The illustration shows only one furnace connected to the hood, but a whole battery of furnaces is connected by an overhead pipe system.

This special feature of cone and hood has also worked out admirably where heavy dust has to be taken from a large area. Fumes or dust that is collected in the center of the cone would tend to fall around the side and would be drawn up the small circular opening.

One common fault in working out dimensions for exhaust systems is simply computing the total area of the branch pipes and considering this as the area of the main exhaust pipe. This we have found to be entirely wrong, our experience showing that 20 per cent. should always be added. If, for example, four 1-in. diameter pipes are united into one large pipe, the area of this should be the sum of the areas of the small pipes, plus 20 per cent. This we have found to be good practice, not only in the exhausting of heavy gases, but also where buffing and emery dust is to be carried away.

GEORGE B. MORRIS.

Buffalo, N. Y.

Unscrewing Cylinder Studs

In 1898 I worked night shift in the repair shop of the Illinois Steel Co. at Joliet, Ill. Early one night word came that the engine running the rod mill was wrecked. The connecting-rod strap had broken and, among other damage, the piston had knocked off the cylinder head, breaking the studs flush with the face of the cylinder. There were 16 studs, 1¼ in. diameter and 2½ in. deep. The foreman said: "Get those studs out; they are in good and tight, and as we have no portable drill you will have to get a ratchet and drill them out."

While clamping the "old man" against the cylinder my helper, an Englishman, said: "Say, young fellow, if you want to get them out in a hurry screw them out with a screwdriver in the ratchet."

I asked him if he had ever seen it done, and he said he had, in the old country. The ratchet I had was well suited for the task, being of heavy construction and having a socket for square-shank drills. So I got the tools with which to fit a screwdriver to it, about ⅛ in. thick at the point. I then chipped a slot across one stud, placed the ratchet in position, and screwed the feed screw out until there was no give to the "old man." Setting the pawl to work left hand, I told the helper to screw her out. Although he had a 20-in. handle, he could not budge it. We then put a 3-ft. length of pipe on the handle and came down with a steady pull, when the stud started.

The rest was easy. As he pumped the handle up and down I eased up on the feed screw. We got all but one out that way, and were drilling that one, along toward quitting time, when the foreman dropped in. Seeing the circle of empty holes, he said: "You are pretty handy with a ratchet drill." Then his eyes fell on the studs lying in a pile and he tumbled.

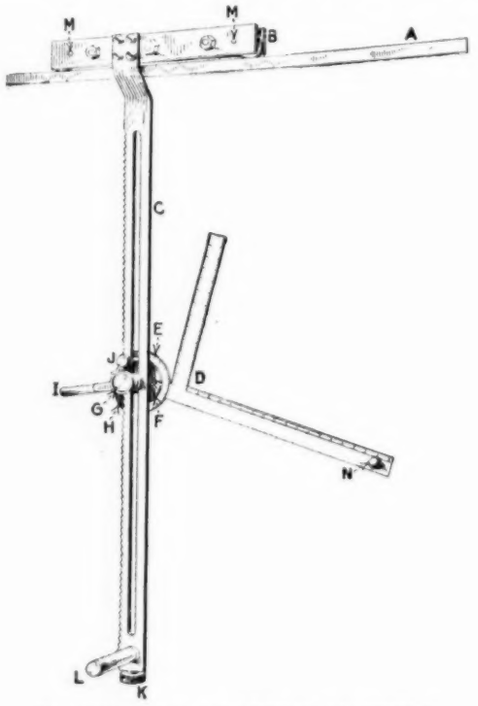
R. L. ABERNATHY.

Davenport, Iowa.

A Drafting Machine for Blackboard Drawing

Anyone who has ever undertaken to make freehand drawings on a blackboard will readily appreciate the value of an instrument that will, in a measure, remove the human element, and incidentally the distortion that is almost sure to characterize all drawings so made.

The instrument described in this article was designed as an accessory to a very fine slate (blackboard) which is



BLACKBOARD DRAFTING MACHINE

part of the equipment in the lecture room serving the metal shops at the Lincoln Park High School, Tacoma, Wash. It is so simple and serviceable that anyone with a rudimentary knowledge of mechanical drawing can use it advantageously, as has been proven in the short time since its completion.

Referring to the cut, *A* is a built-up angle-iron rail extending the entire length of the board. One edge of the angle is finished true and serves as the track upon which the two grooved rollers *M* run; *B* is the carriage and *C* is the vertical bar. Taken together they correspond to an ordinary T-square, and as previously suggested, can be moved to any point along the track. The square *D* is 12x18 in. and graduated, with beveled working edges. It takes the place of both triangles and scales.

The square is carried on the protractor *E*, which is graduated in degrees; *F* is the stationary part of the

protractor and has a tongue that fits into the slot in bar *C*. Through both this tongue and the movable part *E* there is a bolt or center pin on which the parts move. The knurled nut *G* on this pin may be tightened to hold the protractor rigid, as will be described later, while *J* is a plunger dowel pin with a spring to force it into reamed holes in *E*. These holes are spaced 15 deg. apart. There is one to hold the square at right angle with the board, and one each at 15, 30, 45 and 60 deg. off the horizontal, both above and below. Any intermediate degree may be used by tightening nut *G*, this clamping the entire head firmly in place.

Since the ordinary draftsman can draw only one line at a time, this much of the machine takes the place of the T-square, protractor, scales and a full set of triangles. In addition, a cross-hatching, or section-lining attachment, is incorporated into the construction.

The bar *C* is provided with a ratchet rack. In front of the protractor is lever *I*, carried from the center pin and under the nut *G*. From lever *I* is suspended a tool-steel pawl *H*, which serves as a fulcrum for *I*. Behind this is another similar pawl, suspended from the stationary part *F*. By manipulating the lever *I* the entire head, square and all, can be worked up the bar, one-half inch at a time.

When section-lining with this machine, it is necessary to commence at the bottom and work up, the action being both quick and smooth. A simple movement of lever *I* disengages both pawls from the rack and allows the head to descend by gravity. A fiber wheel *K* holds the bar *C* away from the slate. The knurled handle *I* is used when moving the instrument along the rail.

Taken as a whole this device is thoroughly practical and a great time saver. When a good drawing is completed and a record is desired, a photograph is taken and as many prints made as required. Every part of this instrument was made from rough stock by the machine-shop pupils.

R. J. Mullin.

Tacoma, Wash.

Compound Punch and Die for Door Catches

The illustration shows a compound punch and die for making gas-stove door catches. These are made from strip stock which is $\frac{1}{16}$x$\frac{1}{2}$ in. in cross-section and comes in lengths of from 18 to 20 ft. Originally the catches were made in three separate operations, as shown in Fig. 1. They were first punched and cut to length *A*, next partly formed *B*, and then finished to the required shape *C*. This was necessarily a slow and tedious job, as each small piece had to be handled twice, after being cut to length.

The punch now used consists of a cast-iron head *A*, Fig. 2, which carries the two guide pins *B*, the punch *C*, the form *D*, the cutoff *E* and the roller *F*. In operation these parts come into action in the order named. The punch serves to hold the piece in place while the form does the binding and the roller makes the final form during the up stroke of the press.

The die consists of a cast-iron plate *G* to which is bolted a steel block *H* containing the tool-steel piece *J*, the forming punch *K*, the stock guide *L*, the stripper plate *M* and the stock stop *N*. On the edge *J* is the cutoff, the other edge making the square bend, and its center contains the die for the hole. The forming punch is made with two small shoulders on the working end to guide the stock while finishing it. It is returned to position when the die is up by a spring in *O*. The piece *J* is so placed that it gets by *K* and allows it to return to its normal position before *D* reaches the stock on the down-

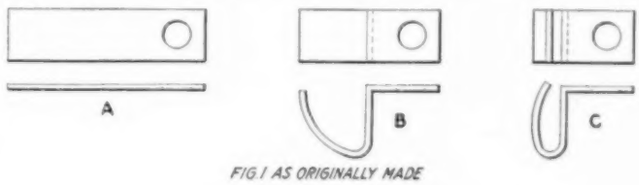


FIG. 1 AS ORIGINALLY MADE

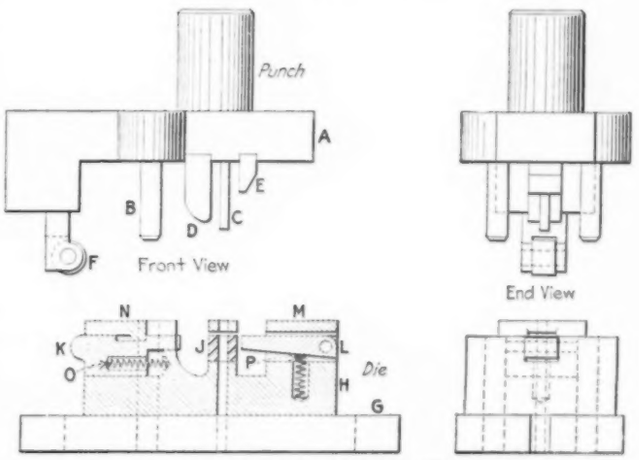


FIG. 2 THE COMPOUND PUNCH AND DIE

COMPOUND PUNCH AND DIE FOR DOOR CATCHES

stroke. The stock guide holds the cutoff end of the stock in line between *J* and *M*, so it may be advanced readily. A spring in *P* brings *L* to position after a piece has been cut off.

The punch and die were operated on a press of the inclined type, so that with the stripper plate cut away on the top, gravity would clear the die from successive pieces.

W. E. Irish.

Rockford, Ill.

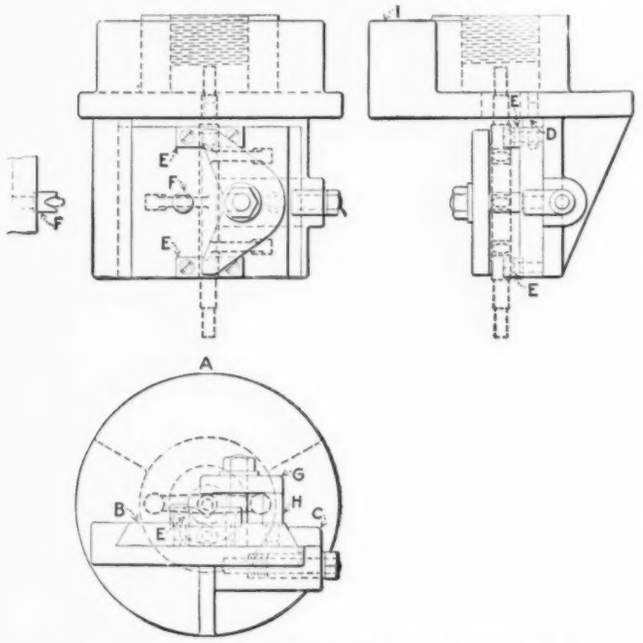
Turning Armed Shaft Ends

The accompanying illustration shows a fixture for turning the ends of a shaft carrying three arms. This was formerly done by centering the ends and revolving the shaft upon the centers of an ordinary engine lathe. The fixture now used consists of a main casting *A*, which is threaded at the back to fit the spindle of a turret lathe. The front part is milled to receive the dovetailed slide *B*, which is clamped in position by the hook-bolt *C* and located lengthwise by the hardened pin *D*. The two V-blocks *E* are secured to the dovetailed slide and are used to center the shaft laterally. The pin *F*, which receives one of the shaft arms, locates it longitudinally. The shaft is held in position by the clamp *G*, which rests on the shaft at the V-blocks *E* and the pin *H*, thus making a three-point bearing. The clamp is C-shaped so that it can readily be put into position or removed. A quarter-turn of the nut secures or releases the shaft.

When one end of the shaft has been turned, the hook-bolt *C* is loosened and the slide *B* is reversed and placed

in position by bringing it against the pin *D* and clamping it with the hook-bolt. It is then ready for turning the other end.

The fixture was counterbalanced by casting an extra amount of metal at *I;* this was afterward drilled in sev-



FIXTURE FOR TURNING ARMED SHAFT ENDS

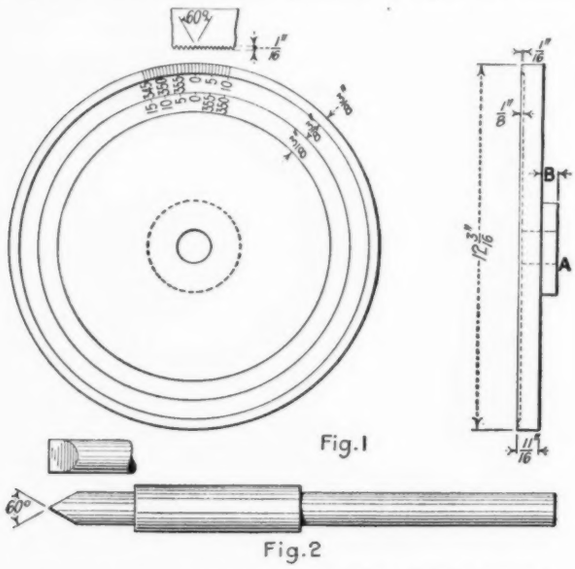
eral places and filled in with enough babbitt metal to balance the fixture perfectly.

S. CLIFFORD.

Philadelphia, Penn.

Dial for Graduating Gun Sights

I recently had occasion to graduate some gun-sight dials which were out of the usual order, the specifications calling for minutes, gradually but not regularly increas-



SPECIAL INDEX PLATE FOR GUN-SIGHT DIALS

ing the interval. The first interval called for 76 min., the second 78 min., the third 81 min., the fourth 85 min., and so on, gradually increasing the interval.

The complete circle containing 360 deg. $\times$ 60 = 21,600 minutes. The dividing head of the milling machine had a 40-pitch screw, making the necessary indexing division equal $\frac{1}{21{,}600} \times 40 = \frac{1}{540}$, requiring a circle with 540 holes. As 540 holes of 1/8 in. diameter and 540 spaces would require a plate about 43 in. diameter, this was not feasible. So, to overcome this difficulty, I designed the plate shown for the dividing head.

It will be observed in Fig. 1 that the plate is adapted for right- or left-hand graduating. This was necessary to facilitate the graduating of the progressively increasing interval, both clockwise and counterclockwise. To simplify the indexing for the operator it was necessary to make up a special table thus:

The first graduation	= 76 min.	=	76 min.	
The second graduation	= 76 min.	+	78 min.	= 154 min.
The third graduation	= 154 min.	+	81 min.	= 235 min.
The fourth graduation	= 235 min.	+	85 min.	= 320 min.
The fifth graduation	= 320 min.	+	90 min.	= 410 min.
The sixth graduation	= 410 min.	+	96 min.	= 506 min.
The seventh graduation	= 506 min.	+	102 min.	— 540 min. = 68
The eighth graduation	= 68 min.	+	109 min.	= 177, and so on.

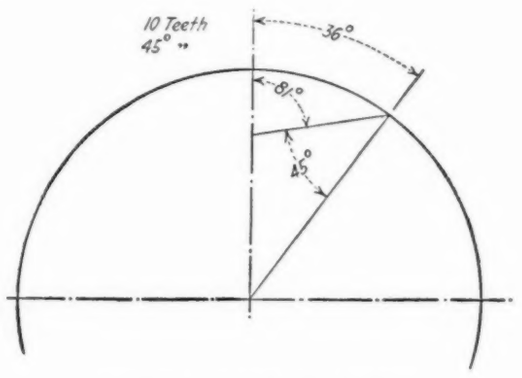
This gives the operator a straight-away movement, which reduces the liability of errors to a minimum. Fig. 2 shows the modified type of index pin to take the place of the usual round one. It has the same angle of 60 deg. as the teeth on the plate shown in the first illustration.

GEO. R. RENFREE.

Philadelphia Navy Yard.

A Simple Method of Selecting Mills for Cutter Teeth

The following rule may prove useful to those who make cutters in small shops that have no drafting room. This rule will eliminate both the laying out and the cut-and-try methods. First determine the number of teeth and the



GETTING ANGLE OF CUTTER

angle desired between the faces and backs of the teeth. Divide 360 deg. by the number of teeth. To this add the desired tooth angle and the result is the angle of cutter to use.

$$\frac{360\ deg.}{Number\ of\ teeth} + angle\ of\ tooth = angle\ of\ cutter$$

To cut a 10-tooth mill with a 45-deg. tooth $\frac{360}{10} + 45$ deg. = 81 deg., which is the required angle of cutter to use.

DANIEL F. MORIARTY.

So. Meriden, Conn.

Discussion of Previous Question

Principle of Similarity in Design

I have read with great interest the discussion by Mr. Booth, on page 247, of Mr. Foster's idea of designing a line of machines by proportion, having wrestled with this problem considerably both in practice and in the classroom. It may be remembered that Mr. Foster's plan is to design one size of a line of machines with great care and make all other sizes to the same proportions by changing the scale of the drawings. As Mr. Booth has pointed out, the idea is not new, and there must be good reasons, therefore, why it has not come into more extended use.

I will readily admit that Mr. Foster's principal contentions may often be correct so far as proportioning

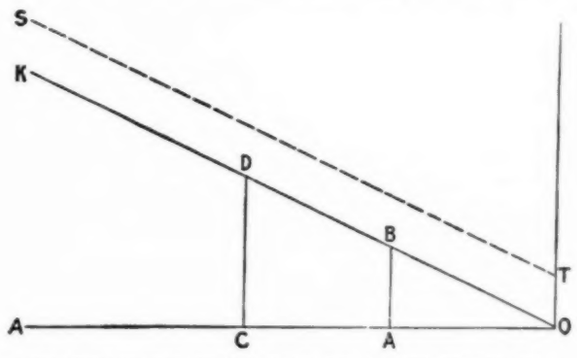


DIAGRAM OF RELATION OF DIMENSIONS IN SIMILAR DESIGN

parts on the basis of stress and strain is concerned, and no doubt in machines such as he discusses—steam engines—the principle can be applied over certain ranges. But there are limitations to the use of the principle even in this and similar classes of machinery and in other classes it must be used with extreme caution. It is not at all clear, as Mr. Booth remarks, that the law may fairly be applied to all other machines.

In general there are three considerations so far as strength is concerned that must be kept in mind in designing machine members: (1) Stresses induced by the energy transmitted; (2) practical allowances for wear, etc.; (3) stresses that are not dependent on the energy transmitted.

The first two of these can often be treated proportionally and, as Mr. Foster notes, the reason why this is not done in many cases is because of lack of skill, as in foundry work. Many machine members, however, are subjected to stresses that are not directly dependent on the energy transmitted and that do not vary with the loads so placed on the member. A notable example of this is that of screw fastenings, the design of which involves items (1) and (3). The stress in the studs in the cylinder head of a steam engine will be due first to the load put upon them in screwing them up to make the joint, and second to the load applied by the steam pressure. In large engines the second is the more important, while in small engines the first is the predominant consideration in design. Thus, suppose a 40-in. cylinder head to have twenty-four 1-in. studs. By the law of proportion a 10-in. cylinder would have twenty-four ¼-in. bolts, which does not seem to be good design, since ¼-in. bolts (the strength of which has no relation to the law of proportion but is a fixed quantity) are too delicate for most erecting engineers. The handle of a hand lever for operating a 10,000-hp. engine will not differ materially from that for operating a 50-hp. engine. Many other examples might be given of factors that do not vary proportionally, but tend to remain constant or to change radically with the size of the machine.

It should be remembered, furthermore, that while the stresses may remain constant with proportional loads and dimensions, the deflection does not in general vary in like manner. It is naturally greater for the larger members and smaller for those of lesser size. Thus if the dimensions of a cantilever beam be doubled and the load increased fourfold, according to the law of proportion, the stress will remain the same but the deflection will be doubled. When it is considered that, after all, stiffness is often more important than strength, it will be seen that the law of proportion is not universally applicable, particularly where the deflection must be kept within definite limits, as is the case in precision machinery.

The arguments here presented are even more clear when applied to the design of electrical machinery. The carrying capacity of the blades of a switch is a function of their cross-section, but the distance between blades is dependent on the voltage which, for any particular system, does not vary. While, therefore, the cross-section of the blades may be designed proportionally the spacing of the blades is not so designed. As a consequence such parts as the bases and handles are not proportional.

The commutator of a small machine will not be found to be a miniature of a larger one, nor will the insulation on the coil windings be proportioned to the size of the machine; but they will be constant in thickness and dependent on the voltage to be withstood.

It is for reasons of this kind that an examination of current practice in any line of machinery will show that while many parts can be and are designed proportionally many others that are affected by factors that tend to remain constant are not so designed. Some years ago John H. Barr made a careful study of current practice in steam-engine design and reported his results to the American Society of Mechanical Engineers in a very clear and valuable paper[1]. Mr. Barr's results show, for instance, that such parts as piston rods, connecting-rods and crankshafts can be designed by rational equations that will give proportional results falling along a straight line passing through the origin of coördinates as does the

[1]See "Trans. A. S. M. E.," Vol. 18, 1897.

line KO in Mr. Booth's diagram, which is reproduced for convenient reference. But the proportions of other parts, the design of which is affected by some of the factors discussed in the foregoing, do not give such results. Thus he finds that in current practice the thickness of cylinder walls could be expressed by the following equation:

$$t = 0.05\ D + 3 \qquad (1)$$

where t is the thickness of the wall and D the diameter of the cylinder. Again, he found that the number of cylinder-head studs could be expressed by the equation

$$n = 0.7\ D \qquad (2)$$

where n is the number of studs and D, as before, is the diameter of the cylinder. And further, he found that the diameter of the studs was expressed by

$$d = \frac{D}{40} + \frac{1}{2} \qquad (3)$$

where d = the nominal diameter of the stud.

Equations (2) and (3) are particularly interesting as they show that the number of studs should not remain constant, as would be the case with true proportional design, but becomes less as the size of the cylinder decreases, while the relative size of the studs increases. The influence of the stress as a result of setting up the stud is here clearly shown, this being the more important stress in small screw fastenings. Equations (1) and (3) when plotted do not pass through the origin of coördinates, but are similar to ST in Mr. Booth's diagram.

It may be objected that Mr. Barr's results are based on practice and may therefore represent only the unscientific work of builders. It should be noted, however, that these results are drawn from a wide field and represent the work of some of our best and most careful engine designers in both small and large work. They may be accepted, therefore, as the average interpretation of carefully computed dimensions.

It would seem that while proportional designing may be often a useful procedure its limitations, like those of "substitutable design" discussed in these columns some time ago, must be carefully considered. The principle evidently can be applied over any range wherein the relative effects of the loads affecting the design do not vary materially; but it cannot be applied to any range wherein any such loads tend to become more or less important. Herein will no doubt be found the reason why designers have, in general, preferred the method of designing a machine at each end of the range, with as many in between as may seem necessary and taking the dimensions of these machines as guiding points on proportional curves.

There is, in fact, the same kind of a reason for not making a small machine a miniature of a larger one as there is for not fixing the price of a small machine as a proportional part of a larger one. In factory costs there are certain elements that increase relatively as the machine becomes smaller and cost-curves like curves (1) and (3) do not, in general, pass through the origin of coördinates. The industrial field contains many other analogous illustrations that are not only interesting but instructive.

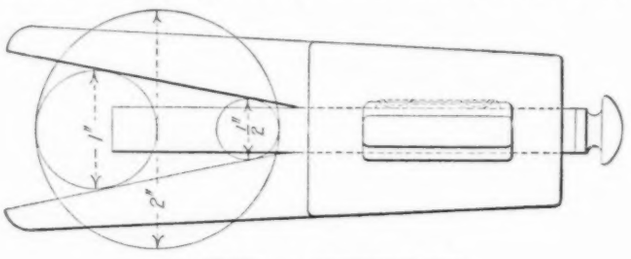
DEXTER S. KIMBALL.

Ithaca, N. Y.

Wanted--A Micrometer

On page 253 H. Woodward Hawkins describes a "V type of micrometer that measures to 0.01 of an inch."

This style of micrometer was, to the best of my recollection, invented by a Major Wade of the United States Army, and Wm. Sellers & Co., Inc., have a drawing of this type of micrometer dated Jan. 22, 1861. Two of these calipers were made, one larger and one smaller than the dimensions given in the accompanying illustration in the early 60's (I cannot now give the date),



WANTED—A MICROMETER

and were used on a good deal of fine work. The one shown is of an intermediate size made considerably later, being dated 1879.

The plunger slides between the two side bars and has a light spring, as indicated on the under side, which gives the necessary friction, while permitting it to slide easily under the finger. One of the beveled sides of the side plates has marked on it a vernier, which, with the graduations on the bar, enables the diameter of a cylinder to be readily measured to 0.001 of an inch. These calipers were made of hardened steel.

I write this in order that credit may be given to the man who originated them for measurements on ordnance work for the United States Army.

J. SELLERS BANCROFT.

Philadelphia, Penn.

Machinist Instruction in the Public School

On page 341, in the article entitled "Machinist Instruction in the Public School," George Heald states that he finds difficulty in finding work "that will instruct the boys in the use of such hand tools as the hammer, chisel and files."

I would like to suggest that if he will build or purchase a small press, either power or hand, and then set his boys to making dies, he will find abundant opportunity for instruction in the use of all the tools mentioned. He could make his own springs, clips, washers, other small sheet-metal parts and, if furniture is also made in the same school, he could make hinges, corrugated fastenings, table-top clips and many other things that would readily suggest themselves. I have done much of this kind of work and know of no other line so well adapted for teaching the use of the file, the chisel and the hammer.

WILBERT S. DREW.

Olean, N. Y.

Flat Spots in Wheels—It has been found that a wheel with a flat spot 3 in. long strikes a blow of 104,000 lb. with the car going at 16 miles an hour and carrying a load of 20,000 lb. Under similar conditions a flat spot 1½ in. long produces a blow of 20,000 lb., and a flat spot 2 in. long a blow of 25,000 lb.

Editorials

Judging from Incomplete Data

Each one of us at times must put something up to someone over us in authority and ask for a decision. With many this is a daily occurrence. The workman is constantly referring things to the foreman, the foreman to the superintendent, the superintendent to the works' manager, the works' manager to the vice-president or president, and he in turn to his executive committee or board of directors. In many such cases the person asking for a decision on some important matter of policy or for authorization for some contemplated act, wishes the verdict to be along a certain line. Even when this wish is very strong, does the asker always realize that the decision is greatly influenced by the degree of completeness of the information he furnishes and the manner in which he presents it?

Many times an adverse decision is given simply because the asker did not present all of the facts that he himself knew and considered when arriving at his own conclusions. It is easy to assume that the other man knows what you know. It is far harder to appreciate what his probable limitations of knowledge are, and it is difficult to gather and marshal the pertinent facts before him in such a fashion that not only will he grasp them all but will give each one its proper weight. Naturally the more important the matter the greater the care that should be exercised in preparing the information upon which it is to be judged.

As an illustration, the consolidation of several manufacturing interests into one organization led to the general determination to concentrate all the machine-shop work in one plant, leaving another as a place for assembling and testing only. This sweeping order compelled the removal of one part of the manufacturing from an old to a new location. What was the outcome? In general, the pieces were produced under the new conditions as cheaply or more cheaply than under the old. But this was not true, in every case, for several pieces cost from 5 to 10 times more than before, with the final result that this portion of the work was retransferred to the old plant. The manager of this shop had originally told the superintendent of the other what his methods were, what machines and tools he used, and the grade of labor he employed. But the superintendent, who was new to the work, failed to grasp this information, with the result that he adopted methods that were much more expensive than those formerly followed and turned out no better product. The consequence was failure on his part and the taking of the work away from him.

Had he fully grasped the conditions of the old plant, or had he judged the situation in view of all the facts, it is more than likely that he would have made as good a record as the old manager. The latter, on the other hand, might have been permanently relieved of this manufacturing burden if he had taken the trouble to make sure that the new man fully appreciated the situation and had complete data at his command before he undertook the new work.

Thus emphasis is justly placed upon the necessity of giving all available necessary information if you are asking for a decision from a superior or are endeavoring to influence the work of another. Like emphasis is justified on the need of making sure that you receive all the necessary facts and give proper weight to them when rendering a decision to someone else.

Electric Arc Welding as a Practical Shop Method

The use of the electric arc in welding work is quite general in foundry and machine-shop practice for such operations as the repairing of defective castings, cutting off risers and sink heads, building up worn parts of machines, welding broken parts of steel castings, and filling up blow holes in partly machined castings. That these processes have increased in general use is evidenced by the fact that there are now on the market efficiently designed arc-welding outfits specially adapted to machine-shop uses.

Nor is arc welding limited solely to these purposes, for modern welding equipment is coming to be generally recommended for certain operations in steel mills, railroad shops, for repairs on electric-railway equipment, and in machine-shop and scrap yards. This list indicates a wide field for the application of electric welding, and its growing use is proof of its economy when rightly applied. The rapid development of arc-welding applications has resulted in a few specialists on the subject as a whole, together with a growing number of operators who are versed in their own particular line. The basic principle of arc welding has been attractive to a number of investigators with various ideas as to how to apply the arc to the metal to be welded.

The different schemes suggested have, however, resolved themselves into two main classes, with the possible addition of a third, this statement being based on the current practice at the present time as reflected in the processes recommended by the manufacturers of welding apparatus. These three schemes include the carbon electrode process, in which the electric arc is drawn between the metal to be welded and a carbon electrode (sometimes called the Benardos method from its originator); the metal electrode process, in which the arc is drawn between the metal to be welded and a metal electrode (a process due to Slavianoff), and the Zerener process, in which the arc is drawn between two carbon electrodes arranged in a holder to form a V shape, the arc being forced toward the metal to be welded by an electromagnet. The last process is not so common as the first two mentioned.

These various schemes suggest certain differences in the results obtainable, and those in charge of general shop methods will do well to gain familiarity with these

differences and the specific process particularly adapted to any given class of work. The economy of the welding process in repair work obviously forms one of its chief attractions. Repairs on record have been made by the welding process at one-fifth the cost of repairing by other methods. In addition to the added facility of the welding method, the material reduction in repair costs is an item worthy of careful consideration. As in other shop methods, the extension of arc welding requires a certain degree of education, a feature which will doubtless follow as data and experience accumulate among present users of the scheme.

Instruction in Machine Practice

Instruction in the engineering schools of this country is gradually undergoing a marked change in its relation to the practical needs of those who are called upon to employ technical graduates. The time-worn attitude of the educational profession to regard the employer as a mere incident in the pathway of the future graduate is now changing to a spirit of coöperation between the teacher and the man who is later to hire the student. It is difficult to understand how these conditions could have been otherwise in past years, but at the same time it should be remembered that engineering education itself is comparatively new and the course of study in classical schools bore a rather indefinite relation to the needs of those who later took up shop work.

One leading institution has outlined its policy, at least as regards one of its engineering departments, by emphasizing the aim to drill its students thoroughly in a few things instead of making an attempt to cover a large number of topics at the expense of thoroughness. This is an important consideration and seems to be in keeping with modern ideas of engineering training. If the plan is carried out generally, it will be necessary in many cases to reduce the already heavily burdened list of subjects which confront the student in so many of the colleges, in order that he may be enabled to concentrate on a relatively small number of branches, and so master what he does undertake.

After all, the student is no exception to the rules which are applied in the shop, where the beginner must of necessity devote his undivided attention to one phase of the work for a certain length of time before his competency becomes established. It is no wonder then that many a student's mind is in a maze immediately after graduation. On entering the shop after the years of student training he finds himself, possibly for the first time, up against a definite and specific problem to which he must give his undivided attention until it has been solved; and he feels lost.

There seems to be a division of opinion on the advisability of devoting any considerable length of time in a strictly engineering course to the practical subjects of machine practice; but one of the foremost institutions of the country has always made a great feature of shop work, and others have followed this lead more or less.

It would certainly be a discouraging condition of affairs to see machine design taught from a textbook as a purely abstract and theoretical subject and without the usual time being spent in the drafting room. Another simple illustration brings out the point involved: In the study of machine-tool operation, some time may be devoted to mastering the theory of electric motors so that the student gains an understanding of electric drive. It is doubtless much better, in presenting the subject of the motor, to deal somewhere in the course with the machine tool it is to drive and then to show how the two may be adapted to each other, than merely to treat of electric motors in a purely theoretical manner without regard to specific application.

Probably there will always be differences of opinion regarding the proper proportions of theory and practice in undergraduate training, but the objective point—the best results—should never be lost sight of, and the results should always be given precedence over personal prejudices.

The Case of Our Submarines

A submarine is a comparatiely small craft. The latest boats for the United States Navy—exclusive of the seagoing Schley type—are something over 200 ft. long, a little more than 20 ft. beam, and weigh perhaps 650 tons. And because the submarine is a small craft duty on it is not the most agreeable kind of service. The space is small and cramped, the work is arduous, the boat is most uncomfortable at sea, and there is constant danger to life. Our own navy has been singularly fortunate, the recent accident to the F-4 being our first submarine disaster. But the story of foreign submarines is a sad one. As a prominent shipbuilder said recently, "Submarining is not a popular sport in any navy."

Therefore in the United States the job of commanding these underwater craft has fallen to ensigns, junior lieutenants, and occasionally to a lieutenant well down on the list. The cases of command by mature, experienced officers are exceptional. The submarine is a complex craft even if it is small. It is propelled on the surface by a pair of Diesel or distillate engines; below water, by a motor driven from a storage battery. It has from one to four torpedo tubes, depending on its size and type. Within it is a maze of pipes, pumps, motors and wires. So its mere operation is no job for a cadet engineer.

Moreover, the type is by no means perfected. Were it so, and if standard instructions for operating could be written, a young officer might do very well as an operating man. He would but have to concentrate on target practice and discipline. As things are, however, there is a tremendous lot of development to be done in machinery, structure, and operation before the submarine can be said to be an effective, dependable weapon.

Therefore we should have seasoned officers in command of these boats; they should be trained for the work and given subordinate duty before being given command. This is merely an application of the teachings of experience that have been followed in the industrial world for many a long day.

This is the discovery made by Captain Grant, to whom the Secretary of the Navy assigned the task of developing our submarine flotilla. He has already set the wheels in motion to correct the conditions. All will watch the progress with great interest. Too often it has been remarked that there is an apparent belief on the part of naval officers that duty goes according to rank, not according to special fitness and training. The *American Machinist* is glad to see reform in the submarines start at the top—the proper place.

Shop Equipment News

Heavy Plain Turning Lathe

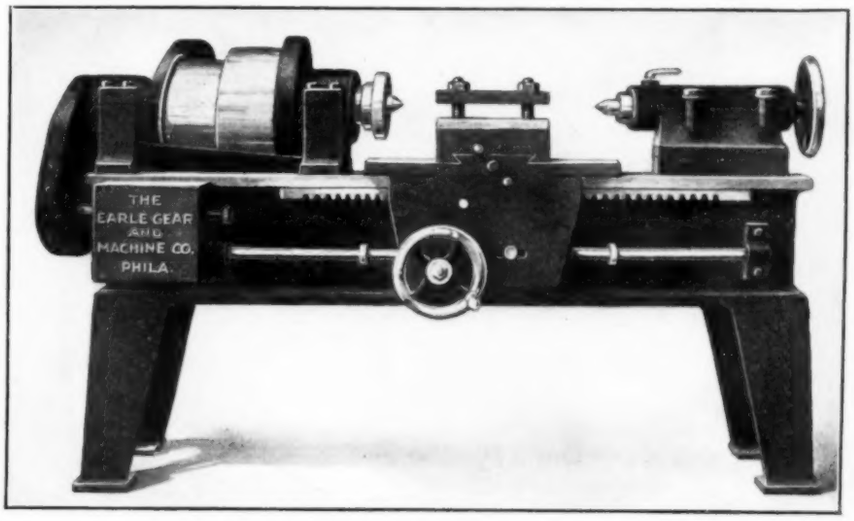
The illustration shows a heavy-duty plain turning lathe designed especially for shell work by the Earle Gear and Machine Co., Philadelphia, Penn.

It will be observed that the design has been reduced to a simple form and rigidity aimed at through heavy construction. The bed, which is 7 ft. long, is cast integral with the headstock in order to secure parallelism between the spindle and the bed in addition to alignment of the carriage and tailstock with the headstock spindle. The bearing surfaces of the bed have been made unusually wide.

The carriage is power-driven and has wide bearings on the bed to facilitate the movement by hand and reduce power when under power-feed. The feed changes are secured through slip gears, plunger-controlled, which are located in a gear box attached to the head end of the bed. A wide range of feed changes is thus provided through a combination of gear-box feeds and spindle feeds. In the belt-driven machine, with two-step cone, the combination with the two-speed countershaft gives eight spindle speeds, or 24 combinations of feeds and speeds, of which the highest is 68 ft. per min. The eight spindle speeds include the two back-gear speeds which are produced through gear ratios of 6¼ to 1.

The headstock spindle is furnished either solid or bored. When fitted with a faceplate, it takes a No. 5 Morse taper, the same as does the tailstock. This spindle is bored only when it is to be used in taking nosing operations. A 1-in. hole passes through the entire spindle. This is calculated to add stiffness, reducing weight at the same time. At the faceplate end, a larger hole is recessed into it in a way that provides, first, sufficient depth for any length of shrapnel shell having a diameter within the machine's capacity; secondly, a bearing surface for the chuck jaws sufficient to assure a tight grip, without digging into the stock; thirdly, the required amount of protrusion beyond the chuck jaws to permit complete nosing with one setting; and, fourthly, minimum overhang beyond the chuck, which prevents chattering and insures smooth, accurate work. The flat bearing guides on the bed are planed and scraped. Adjusting gibs are provided in order to take up wear, so as to retain alignment. Lubrication of the main bearings is by ring oilers.

The machine shown has an 18-in. swing over the bed and a 10-in. swing over the carriage. The length of bed is 7 ft. and the height from the floor to the center is 40 in. The machine weighs approximately 3,650 lb. It is made in three sizes: 18 in. by 7 ft.; 20 in. by 8 ft.; and 24 in. by 8 ft.



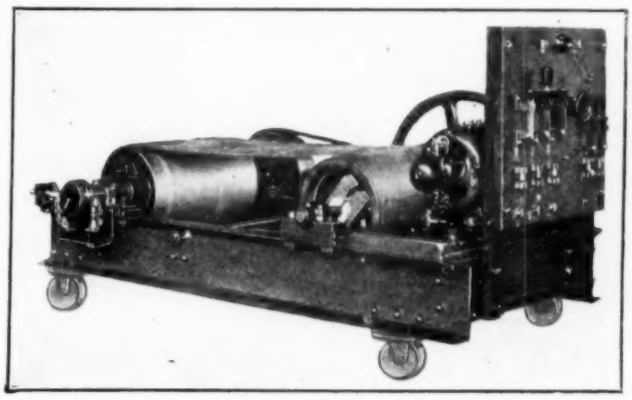
SIMPLE PROJECTILE TURNING LATHE

Portable Magnetic Separator

The illustration shows a portable magnetic separating outfit built by the Cutler-Hammer Clutch Co., Milwaukee, Wis. The separator is used in various parts of the plant for removing magnetic content from brass. The outfit is moved to where a separation is to be made and the material conveyed onto the belt in readily distributed quantities.

The brass is projected beyond the pulley, free of magnetic pieces, since the latter hug the belt in passing over the magnetized pulley and are dropped beneath the belt where it leaves the pulley separate receptacles can therefore be easily arranged.

The direct current for the magnetic pulley is furnished by the small 110-volt generator which is driven by the same induction motor that drives the pulley. The small panel mounted at one end of the frame carries the three-pole motor knife-switch and fuses, the double-pole generator knife-switch and fuses, back-of-board type dynamo field-regulator and pilot lamp.

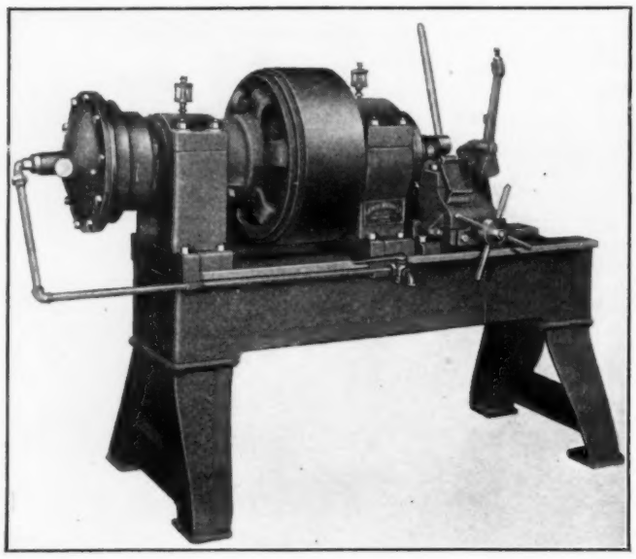


PORTABLE MAGNETIC SEPARATOR

Shell-Band Turning Lathe

The machine shown is in general similar to the one described on page 1017, Vol. 42, but has been especially developed for the larger high-explosive shells by the Jenckes Machine Co., Sherbrooke, Canada.

The bed is of the heavily ribbed flat-top type, mounted on legs of the standard type. In place of the regular



SHELL-BAND TURNING LATHE

headstock, two heavy capped bearings are used, each one secured to the bed with four bolts. The caps are machine fitted and also held by four studs. The rear bearing, 6 in. diam. by 7 in. long, is babbitted, hammered in, bored and finally scraped to the spindle; the forward bearing is 9¾ in. diam. by 7 in. long. The spindle is a steel casting, hollow, turned all over and finished by grinding. The drive is through a 22x8-in. clutch pulley, mounted on the spindle and bushed with bronze.

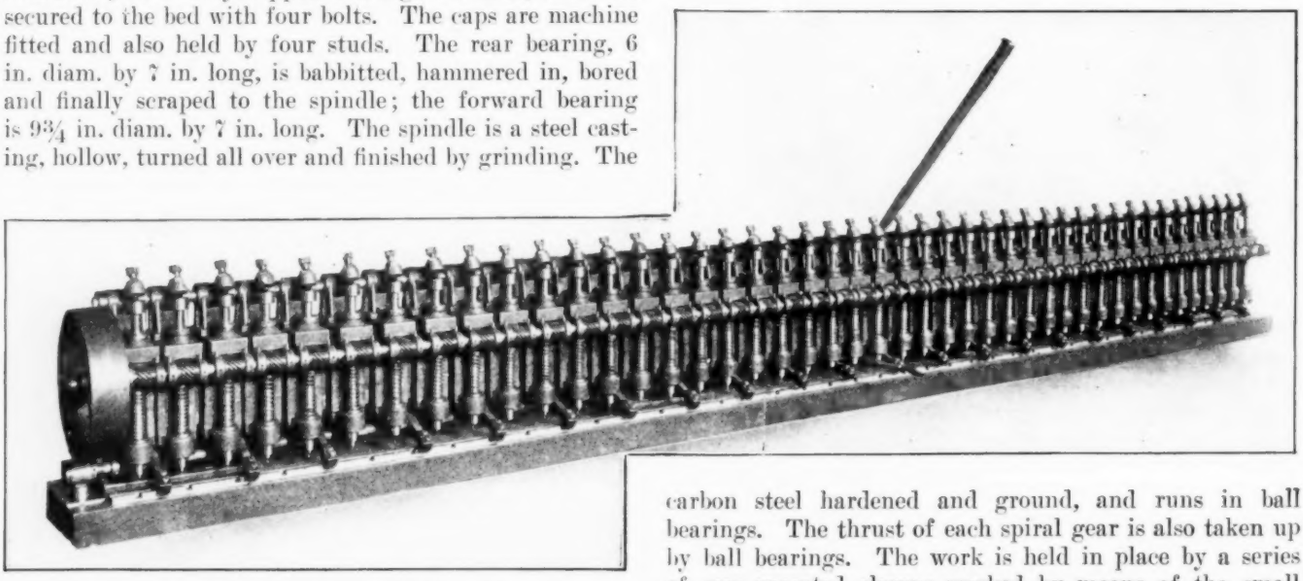
The clutch is a hard-maple cone, the full size of the inside of the pulley, and is operated by a compressed-air piston controlled by a valve within reach of the operator's hand. The clutch mechanism is all built into the spindle and when in use has no tendency to move the spindle endwise or cause end friction. Means are provided for taking up the end-play of the spindle should any wear occur. The chuck, operated by compressed air, is of the draw-in type, and is built into the enlarged end of the spindle and controlled by the same valve that operates the clutch. The tool-slide base is very heavy and clamped immovably to the lathe bed.

The front or roughing tool is fed in by screw and handwheel to a dead stop and leaves a light cut for the finishing tool. The finishing tool is mounted to the rear of and above the work. The tool can be adjusted to pass down behind the shell and in passing shave the band to size. The feed is by lever and pinion. The tools are held in steel blocks by a clamp gripping the dovetailed portion of the tool.

A 44-Spindle Drilling Machine

The machine shown was built by the Gem City Machine Co., Dayton, Ohio, for drilling and countersinking the holes in aluminum automobile retaining-strips. There are 44 spindles in all, and each carries a combination drill and countersink. The machine is so constructed that either all or any less number of spindles may be used as desired. The spindle brackets are clamped to the back support in such a way as to be easily moved to the right or left to obtain the correct drilling position.

A series of spiral gears is carried on a shaft running the entire length of the machine and these gears mesh with suitable pinions on the spindles. All the spindles in position are depressed at once by means of the upper lever shown at the middle of the machine. When released, spiral springs push the spindles upward away from the work. Each spindle is made of special carbon steel hardened and ground, and runs in ball bearings. The thrust of each spiral gear is also taken up by ball bearings. The work is held in place by a series of cam-operated clamps worked by means of the small lever shown on the bed directly under the spindle-operating lever. The bed is made from a piece of 12-in. channel iron 14½ ft. long, and the entire machine weighs about 2,100 lb.



A 44-SPINDLE DRILLING MACHINE

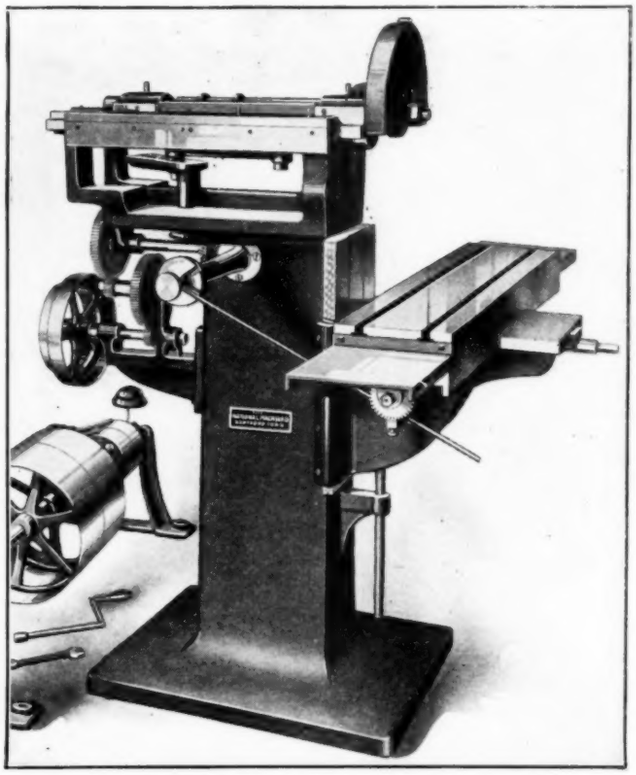
A Surface Grinder with Traversing Wheel

This surface grinder is of the traversing-head type, the wheel being mounted in the ram and moved back and forth across the work in a manner somewhat similar to that of a shaper. This movement is easily adjusted to

the length of stroke desired by means of the slotted crank under the slide.

The feed is entirely automatic in either direction when so desired. The spindle runs in phosphor-bronze bearings with guards to exclude dust.

While generally used for finishing flat surfaces on punches and hardened parts, it is now being largely



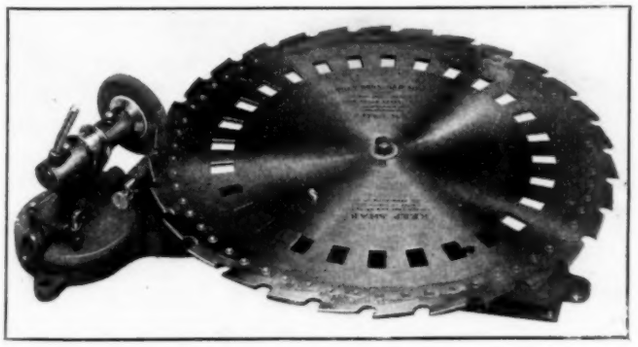
TRAVERSING-HEAD SURFACE GRINDER

utilized for sharpening powder-cutting knives used in the manufacture of explosives. This machine is built by the National Machine Co., Hartford, Conn.

Saw-Tooth Grinder

The saw-tooth grinder shown was especially designed for sharpening inserted-tooth milling saws.

The saw is placed, as shown, on the table, which is adjustable so that it may be raised or lowered to permit the



SAW-TOOTH GRINDER

grinding wheel to swing to the bottom of the tooth. The grinder head may be set so that any desired angle of tooth or hook may be ground. A set-stop is provided on the grinder head so that the wheel cannot grind into the body of the saw.

This grinder is a recent product of the Huther Bros. Saw Manufacturing Co., Rochester, N. Y.

Crankshaft Driving Chucks

By Arthur Driver

In many shops where crankshafts of the single, double, triple or quadruple types are turned, it is quite common to find that the driving chucks used when turning the crankpins have projections cast upon the sides, the positions being relative to the crankpin centers and the bases machined, as shown in Fig. 1. The object of this is to facilitate the setting by placing the chucks loosely upon the shaft, and then upon a surface plate to align them.

If it be a single-throw shaft, the crank web is set to a square and the chucks made secure by setscrews. If, however, the shaft is a multiple-throw, then one web is set to the square and the remaining by means of a surface gage. This method is slow, and the chucks shown in Figs. 2 and 3 were designed to overcome this objection. The bodies of these chucks are made of cast steel and have upon their backs a turned taper projection concentric with the hole to receive the crankshaft. This feature permits of various loose mild-steel throw-plates, which are interchangeable, being attached to the chuck as required. These are located by the taper projection and held in position by bolts.

It will be noticed that each plate has lines cut at right-angles by a fine V-shaped tool across its back and edge

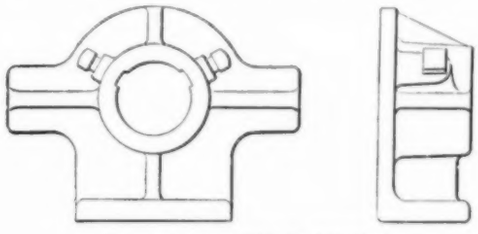


FIG. 1. OLD-STYLE CHUCK

and that these lines pass through the centers of the plate and the taper hole. They are for setting purposes.

It is shown in Fig. 2 that the throw-plate is provided with six holes; therefore, this plate can be used for single, double, triple or quadruple crankshafts, the pins of which are at the same throw.

Referring to Fig. 4, a height gage is shown at *A* on the lathe bed; the use of this gage is as follows: Taking the middle web first, its center is found by means of a pair of hermaphrodite calipers, and the line is set to coincide with the height gage, as indicated. The shaft is next held in this position with the chucks at one end. The other end is then adjusted so that the relative lines upon the throw-plate coincide with the height gage and the center of the middle web. The chucks are now made secure by setscrews and the remaining webs tried over in the same way, thus showing whether or not the shaft has been forged correctly. Should the throws, however, be a little out, it is necessary to divide the error between the pins or the webs. The chucks are in that event locked in position and placed between the lathe centers. The crankshaft is then ready for the turning of the pins and the inside webs.

This method of chucking and driving crankshafts, even

with the improvements described, does not permit of heavy cutting, owing to the lack of rigidity, and is, therefore, not as efficient as it should be. Those who have engine lathes only for this class of work will no doubt find the following method more desirable.

In special crankshaft lathes it is the practice to drive by means of the adjacent web when turning the pin. This not being permissible, the next best thing must be done; that is, to drive by the web nearest the faceplate, as in Fig. 5. This is practically self-explanatory, though a little description will not be out of place.

On the faceplate of the lathe is secured the cast-iron chuck *A*, which is located by a taper spigot *B* turned upon its back, engaging a recess in the faceplate. The front (which is open) is bored and recessed to receive various throw-plates, as *C*, which are held to the chuck and driven by four equally spaced bolts. These plates are made from cast iron and are sufficiently strong to prevent buckling. Across the front of each are cut at right-angles two fine lines which pass through the centers of four holes placed at right-angles and made big enough to receive the largest diameter of shaft of that throw. Thus each of these plates will accommodate crankshafts of four various throws. This permits of the use of reducing bushings to suit shafts of smaller diameters.

Around these holes are placed three or four smaller tapered recesses to engage a spigot which is integral with a cast-steel driver having two adjustable setscrews, thus providing for varying widths of shaft webs. This driver is held in place by the bolt, which can be got at through the hand holes in the chuck body.

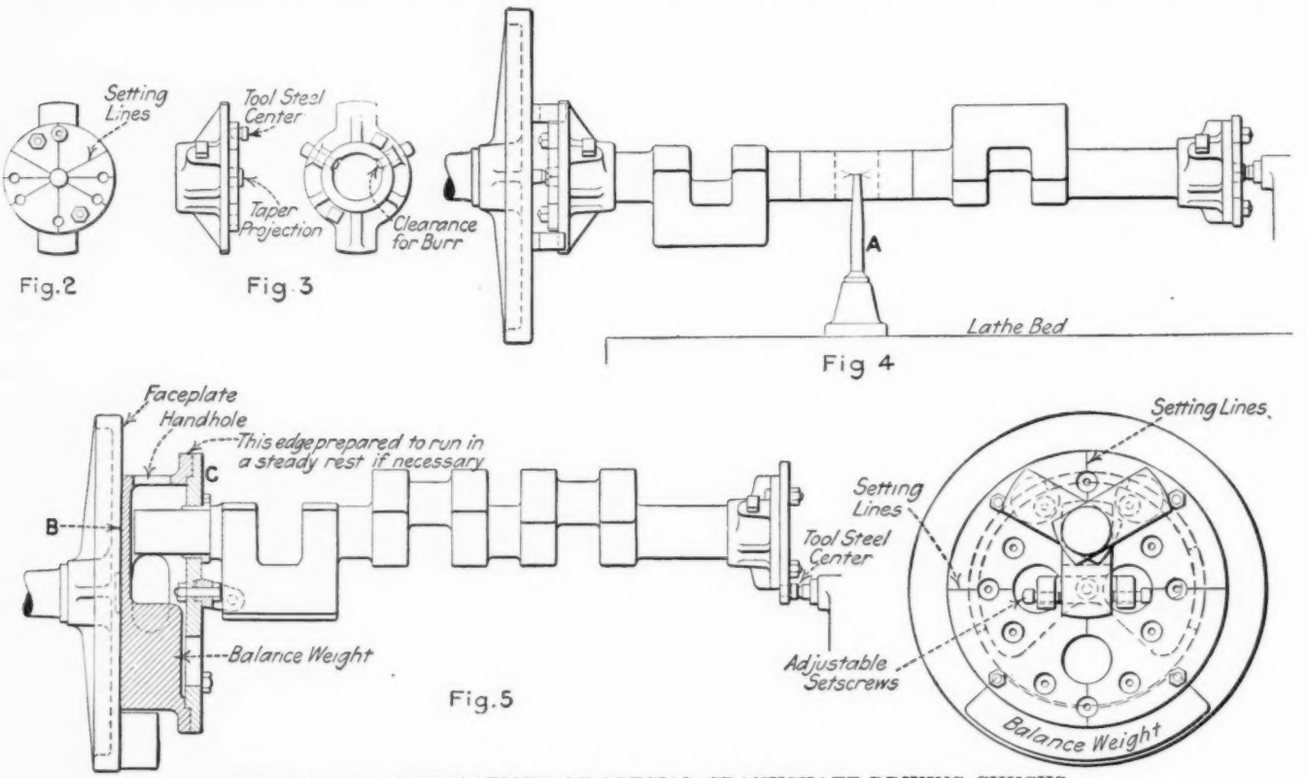
In the preparation of the shaft, one end is turned to fit the reducing bushing, which is placed in the cast-iron chuck with the driver engaging the adjacent web; the other end is carried in the chuck with loose plate upon the back, which has been set approximately by the eye.

The set-up is now placed in the lathe and located by the height gage, as described, with this exception: Instead of twisting the chuck at the driving end until the center lines coincide with that of the web, the web itself is adjusted by means of the setscrews in the driver until its center is in line with the setting mark across the face of the throw-plate. The outer end is set as before.

The chuck has a balance weight cast integrally, and if this is not sufficient, more weights may be placed upon the faceplate, or the chuck itself may be prepared to receive extra weights upon its periphery.

If the crank webs have to be crowned, this must be done from two centers; that is, the outer ends of the web are turned from the shaft center, and the inner ends, from the pin center. If, however, this is not acceptable, and it is desirable that the crowning be done from a common center midway between the crankpin and shaft center, it will be necessary to have throw-plates made with two holes only, more holes being prohibited through the smallness of eccentricity required for crowning purposes.

As regards the chuck at the outer end, all that is necessary is that there be more holes in the mild-steel throw-plate, which can be provided in most cases.



FIGS. 2 TO 5. APPLICATIONS OF SPECIAL CRANKSHAFT DRIVING CHUCKS

PERSONALS

H. L. Wittstein, efficiency engineer of the Knox Motors Co., Springfield, Mass., has resigned to accept the position of assistant to the manager of the Standard Fuse Corporation, Paulsboro, N. J.

A. W. Draeseke, of the John Bertram & Sons Co., Dundas, Ontario, has been made secretary of the Engineers' Committee for Standardizing Drafting Room Practice of the various plants of the Niles-Bement-Pond Co. Carl L. Grohmann, of the Pratt & Whitney Co., was elected chairman. The other members of the committee are G. E. Greenleaf, Pond Co.; A. E. Hogrebe, Crane Dept.; Edward Wray, Bement-Niles Works; Otto Pabst, Niles Works.

Prices--Materials and Supplies

METALS—In a weak market, electrolytic copper is selling at 17.50c. and lake at 18c. Very little buying is being done in tin and the quotation has reached 33.25c. Lead is still firm at 4.90c. in a rather lifeless market. The price of spelter is the same as a week ago, selling at 15c. Solder has dropped to 20.50c.

PIG IRON—Quotations were current as follows at the points and dates indicated:

	Sept. 10, 1915	Aug. 13, 1915	Sept. 10, 1914
No. 2 Southern Foundry, Birmingham	$11.00	$11.00	$10.00
No. 2X Northern Foundry, New York	16.25	15.25	14.50
No. 2 Northern Foundry, Chicago	14.00	13.75	14.00
Bessemer, Pittsburgh	16.95	15.95	14.90
Basic, Pittsburgh	15.45	14.90	13.90

MISCELLANEOUS METALS—NEW YORK

	Sept. 10, 1915	Aug. 13, 1915	Sept. 10, 1914
	Cents per pound		
Copper, electrolytic (carload lots)	17.50	18.50	12.50
Tin	33.25	35.00	38.00
Lead	4.90	4.50	3.90
Spelter	15.00	22.00	6.15
Copper sheets, base	23.00	24.00	18.00
Copper wire (carload lots)	28.00	25.00	15.00
Brass rods, base	26.25	26.25	13.62½
Brass pipe, base	31.00	31.00	16.00
Brass sheets	26.25	24.00	13.87½
Solder ¼ and ½ (case lots)	20.50	25.00	23.00

STEEL SHEETS FROM JOBBERS' WAREHOUSE, NEW YORK

	Sept. 10, 1915	Aug. 13, 1915	Sept. 10, 1914
	Cents per pound		
No. 28 Black	2.60	2.60	2.70
No. 26 Black	2.50	2.50	2.60
Nos. 22 and 24 Black	2.45	2.45	2.55
Nos. 18 and 20 Black	2.40	2.40	2.50
No. 16 Black	2.35	2.35	2.45
No. 14 Black	2.25	2.25	2.35
No. 12 Black	2.20	2.20	2.30
No. 28 Galvanized	5.00	5.50	3.70
No. 26 Galvanized	4.70	5.20	3.40
No. 24 Galvanized	4.50	5.05	3.25

STEEL SHAPES FROM JOBBERS' WAREHOUSE, NEW YORK

	Sept. 10, 1915	Aug. 13, 1915	Sept. 10, 1914
	Cents per pound		
Steel angles base	2.05	1.95	1.85
Steel T's base	2.10	1.95	1.90
Machinery steel (bessemer)	2.00	1.90	1.85

COKE—Prompt furnace coke is low, but with limited offerings, trade trying to develop a price for first-half deliveries. Production has slightly increased and shipments slightly decreased. The market is quotable as follows: Prompt furnace, $1.60@1.75; September furnace, $1.75; furnace to Jan. 1, $2; prompt foundry, $2.25@2.60; contract foundry, $2.30@2.60, per net ton at ovens.

STANDARD PIPE—On both black and galvanized pipe the discount remains unchanged. Some jobbers may shade prices, but on carload lots f.o.b. Pittsburgh the following discounts prevail:

	Black	Galvanized
¾ to 2-in. steel, butt welded	79%	63½%
2½ to 6-in. steel lap welded	78%	62½%
7 to 12-in. steel lap welded	76%	58½%

At this rate prices are as follows:

Diameter	Cents Black	Cents Galvanized	Diameter	Cents Black	Cents Galvanized
¾-in.	2.42	4.19	5-in.	32.56	55.50
1-in.	3.57	6.20	6-in.	42.24	72.00
1¼-in.	4.83	8.39	7-in.	57.12	98.77
1½-in.	5.77	10.03	8-in.	60.00	$1.03
2-in.	7.77	12.55	9-in.	82.80	1.43
2½-in.	12.87	21.93	10-in.	98.99	1.70
3-in.	16.83	28.68	11-in.	$1.11	1.92
4-in.	23.98	40.87	12-in.	1.21	2.16

SEAMLESS DRAWN TUBING (Iron Pipe Sizes)—The call for brass and copper shapes continues excellent. The base price is now 31c. for brass and 29.50c. for copper. For immediate stock shipment from warehouse dealers 3c. is added to this price, which offers the following quotations:

Diam., In.	Brass	Copper	Diam., In.	Brass	Copper
¾	34.00	32.50	3½	35.50	33.50
1	34.00	32.50	4	36.50	34.50
1¼	34.00	32.50	4½	38.50	36.50
1½	34.00	32.50	5	40.50	38.50
2	34.00	32.50	6	41.50	39.50
2½	34.00	32.50	7	43.50	41.50
3	34.00	32.50	8	45.60	43.60

MACHINE BOLTS—From New York warehouse, the present discount is 75 and 5% off list. This is for sizes from ⅜ in. by 4 in. and smaller. At this rate prices are as follows per 100:

	Diameter ¼	⅜	½	¾	⅞	1 In.
1½ in.	$0.40	$0.57	$1.24	$1.82	....	....
2 in.	.42	.61	1.32	1.96	$2.66	....
2½ in.	.44	.65	1.42	2.09	2.83	....
3 in.	.45	.68	1.50	2.22	2.99	$4.43
3½ in.	.45	.72	1.60	2.35	3.63	4.44

For larger and longer sizes up to 1 in. by 30 in., the discount is 70 and 10% off list.

MONEL METAL—The following are the prices per net lb. for hot rolled rounds and flats. For prices of square and hexagonal bars add 2c. to the corresponding size of the rounds (mill lengths 8 to 14 ft.):

HOT ROLLED ROUNDS

Size, In.	10,000 Lb. and Over	2,000 Lb. and Over	500 Lb. and Over	Less Than 500 Lb.
⅜ to ⅝	28.75	29.75	30.25	31.25
⅝ to 1⅞	28.00	29.25	29.75	30.75
1⅛ to 2⅞	28.00	30.25	30.75	31.75
2⅛ to 4	30.75	31.25	31.50	32.50

HOT ROLLED FLATS

Thickness, In.	Width in Inches ½ to 1	1⅛ to 2¾	2⅞ to 6
⅛ to ⅞	33.00	32.00	....
¼ to 1	32.00	31.00	30.00
1⅛ to 2	....	30.00	29.00

For cutting to any specified length not shorter than 1 ft. add 1c. per lb.

COLD DRAWN STEEL TUBING—The following prices are net per ft. in cents from jobber's warehouse New York.

Thickness of Wall, B.W.G.	Outside Diameter in Inches ¼	⅜	½	⅝	¾	⅞	1	1¼
22	6.75	6.75	6.75	7.37	8.68	9.35	10.26	12.42
18	7.92	7.92	7.92	9.25	11.21	12.32	13.50	16.00
16	9.3	9.3	9.3	11.8	13.44	15.12	17.16	20.09
13	12.32	12.32	12.32	14.58	17.16	20.00	22.54	27.73
11	.....	.....	.....	16.83	20.09	23.52	26.79	32.85

ANTIMONY—Very little interest is shown in the market and prices remain unchanged. Cookson's sells at 45 to 50c. per lb., Hallett's 42 to 45c., other brands 36 to 38c. These quotations are for small lots, jobbers' warehouse.

OLD METALS—With no improvement in the market prices are nominal. Dealers' prices in New York are as follows: Copper, heavy and crucible, 15c.; copper, heavy and wire, 14.75c.; copper, light and bottoms, 12.5c.; brass, heavy, 10c.; brass, light, 8.5c.; heavy machine composition, 11.5c.; No. 1 yellow rod brass turnings, 11.5c.; No. 1 red brass or composition turnings, 10.5c.; lead, heavy, 4c.; lead, tea, 3.75c.; zinc, scrap, 10c.

SWEDISH (NORWAY) IRON—No sign of improvement has appeared and dealers refuse to make any quotations.

DRILL ROD—This sells to consumers at the following discounts: Third grade, 65% off; second grade, 40% off, and first grade, 25% off.

At these discounts the net prices are as follows:

ROUND POLISHED DRILL ROD

Size, in.	First Grade	Second Grade	Third Grade
1/64 to 1½ in.	37.50c.	30.00c.	17.50c.
1/64 to ½ in.	41.25c.	33.00c.	19.25c.
1/64 to ⅝ in.	45.00c.	36.00c.	21.00c.
0.178 to 0.4218	56.25c.	45.00c.	26.25c.
0.125 to 0.270	62.25c.	49.80c.	29.05c.
0.202 to 0.120	67.50c.	54.00c.	31.50c.

New and Enlarged Shops

METAL WORKING

NEW ENGLAND STATES

The Jones & Lanson Machine Co., Springfield, Vt., has awarded the contract for the construction of a one-story, brick and steel, 120x125-ft. addition.

J. A. W. Silver, 18 Tremont St., Boston, Mass., will build a one-story, 72x132-ft. garage. The estimated cost is $25,000. C. A. & F. N. Russell, 50½ Warren St., Roxbury District, Boston, Mass., is Arch. Noted Aug. 19.

Bids are being received by the Adams & Sewett Cleaning Co., 130 Kemble St., Roxbury District, Boston, Mass., for the construction of a one-story, 35x55-ft. garage.

William B. Rice, 17 Ipswich St., Boston, Mass., has awarded the contract for the construction of a two-story, 50x121-ft., brick addition to his garage. Luther C. Greenleaf, 101 Tremont St., is Arch.

Fire, Sept. 4, damaged the iron foundry of the Hunt-Spiller Mfg. Corporation, 373 Dorchester Ave., Boston, Mass. Loss, $1,000.

W. S. Tribon, 180 Arlington St., Wollaston District, will build a one- and two-story garage at Quincy, Mass., by day labor.

Bids are being received by Eugene Schwender, Arch., 161 Devonshire St., Boston, Mass., for the construction of a one-story, 21x31-ft. garage for G. H. Bossert, Wellesley, Mass.

James H. Nagle, 46 Chatam St., Providence, R. I., has awarded the contract for the construction of a one-story, 40x 40-ft., concrete public garage on Branch Ave.

The Asa S. Cook Co., Hartford, Conn., has awarded the contract for the construction of a plant to cost $40,000. John F. Cook is Secy. and Gen. Mgr. Noted Aug. 26.

The Hartford Automobile Parts Co., Colt West Armory Blk., Hartford, Conn., will build a two-story, 60x200-ft. plant in New Britain, Conn.

N. B. Whitfield, 277 Park St., New Haven, Conn., plans the construction of a garage. R. W. Foote, 185 Church St., is Arch.

The Manufacturers Foundry Co., Waterbury, Conn., will build a 53x143-ft. plant at Platts Mills.

Bids are being received by J. M. Mulgrew, care of Henry Marvin, Arch., 324 Main St., Stamford, Conn., for the construction of a garage at Shippan Point, Conn.

The Smith & Winchester Co., South Windham, Conn., has awarded the contract for the construction of a two-story, 60x127-ft. addition to its factory to cost $20,000. Adolph Suck, 94 Arlington St., Hyde Park, Mass., is Engr.

MIDDLE ATLANTIC STATES

The Niagara Automobile Co., Buffalo, N. Y., recently incorporated, will build a factory at Main and Carlton St. for the manufacture of automobiles. G. H. Poppenberg is Pres.

The Benford Mfg. Co., manufacturer of spark plugs, Mt. Vernon, N. Y., will construct an addition to its plant estimated to cost $15,000.

The Tropenas Converter Co., 50 Church St., New York, N. Y., is in the market for a testing machine of from 100,000 to 200,000 lb. capacity, preferably second hand.

The Mitchell Machine Co., Poughkeepsie, N. Y., will build an addition to its plant.

The Stevens-Duryea Automobile Co. will build a new factory at Rochester, N. Y.

The C. & C. Electric & Mfg. Co., Garwood, N. J., is in the market for shell making machinery, being especially interested in single purpose lathes.

The plant of the Howard Demountable Rim Co., Trenton, N. J., recently destroyed by fire, will be rebuilt. Noted Aug. 19.

The Hope Machine Co., Philadelphia, Penn., will build a two-story garage and machine shop at 2311-13 North Philip St.

The contract has been awarded for the construction of a 110x180-ft. factory for the National Umbrella Frame Co., Belfield and Stenton Ave., Philadelphia, Penn.

The Packard Motor Co. will build a three-story, brick and stone building at Baum Blvd. and Enfield St., Philadelphia, Penn., at an estimated cost of $300,000.

The Philadelphia Steel & Forge Co., Philadelphia, Penn., will build a one-story, 49x64-ft. addition to its plant at Milnor and Bridge St., estimated to cost $1,000.

The Southwark Foundry & Machine Co., Fifth St. and Washington Ave., Philadelphia, Penn., plans to enlarge and remodel its plant.

The Standard Chain Works, 41 Small Bldg., York, Penn., will build a one-story, 220x330-ft. factory. The estimated cost is $36,000.

The Kennedy Foundry Co., Baltimore, Md., plans to construct a three-story addition to its plant at Wells and Charles St.

Plans have been prepared for the construction of a one-story, 180x425-ft. brick and steel machine shop for the America Steel Co., Sparrows Point, Md. (Baltimore post office).

The contract has been awarded for the construction of an addition to the plant of the Poole Engineering Co., Woodberry, Md., Baltimore post office. The new plant will be used for the manufacture of war munitions and is estimated to cost $80,000.

SOUTHERN STATES

The city will construct a one-story, 30x50-ft. garage at Huntington, W. Va., for the State Hospital. The estimated cost is $3,000.

The Sturn Machine Co. will construct a foundry at Wheeling, W. Va. E. W. Krause is Mgr.

The Dudley Motor Co. has awarded the contract for the construction of a garage at Columbus, Ga.

The Co-Operative Munitions, Engineering & Shipbuilding Co., Clermont Harbor, Miss., contemplates the construction of a plant at Macon, Ga., for the manufacture of war munitions.

The Southern Express Co. will construct a 30x60-ft. garage at Tampa, Fla. The estimated cost is $3,500.

The Nashville Bridge Co., Nashville, Tenn., will equip a plant for the manufacture of shrapnel.

Bids will soon be received for the construction of a garage at Louisville, Ky., for Brainerd Lemon. Ward & Glossop, 1501 Lincoln Bank Bldg., is Arch. Noted Aug. 19.

Bids are being received by Ward & Glossop, 1501 Lincoln Bank Bldg., Louisville, Ky., for the construction of a garage at Anchorage, Ky., for Lewis Doehoefer.

MIDDLE WEST

W. S. Keever, Beverly, Ohio, has awarded the contract for the construction of a one-story, 26x28-ft. garage, estimated to cost $1,500.

The Bonnot Co., manufacturer of clay working machinery, Canton, Ohio, will build a new machine shop.

Plans are being prepared by Moritz Sax, Arch., 1011 Fourth National Bank Bldg., Cincinnati, Ohio, for the construction of a garage for Harry M. Levy, 2933 Fairfield Ave.

The contract has been awarded for the construction of a garage for the Park Garage Co., 2005 Symmes St., Cincinnati, Ohio, estimated to cost $10,000.

The Lohse Automobile Improvement Co., Cleveland, Ohio, has leased a building at West 17th St. and Big Four R.R. and will equip it for a machine shop and brass foundry.

The Park Drop Forge Co., Cleveland, Ohio, will construct an addition to its plant on East 79th St., estimated to cost $2,000.

Bids are being received by H. W. Wachter, Arch., 908 Nicholas Bldg., Cleveland, Ohio, for the construction of a one-story, 50x70-ft. garage for Johnson Thurston, 844 Spitzer Bldg. Estimated cost, $5,000.

The contract has been awarded for the construction of a one-story, 23x50-ft. garage for T. Zingale, 2538 East 19th St., Cleveland, Ohio. Estimated cost, $2,500.

George E. Mitchell, 320 High St., Columbus, Ohio, will build a two-story garage at 103-111 South Front St., at an estimated cost of $6,200.

Work has been started on the construction of a factory for the Rundle Novelty Co., manufacturer of juvenile vehicles, Columbus, Ohio.

The Platt Iron Works, Keowee St., Dayton, Ohio, has awarded the contract for the construction of an addition to its plant. Estimated cost, $35,000.

The Dennison Foundry & Machine Co., Dennison, Ohio, plans to enlarge its plant.

The Peerless Drawn Steel Co., Massillon, Ohio, has increased its capital stock from $100,000 to $200,000 and plans to enlarge its plant.

The Ohio Fuel Supply Co., Mt. Vernon, Ohio, is building a three-story, 40x140-ft. machine shop.

Plans have been prepared for the construction of an addition to the plant of the Nolte Brass Works, Springfield, Ohio.

The Nordyke & Marmon Co., Indianapolis, Ind., manufacturer of milling machinery and automobiles, will build a factory at Nordyke Ave. and the Belt Line. Estimated cost, $10,000.

We are advised that the Crown Fender Co., 302-304 Kerr Bldg., Detroit, Mich., will build an 80x400-ft., brick and concrete factory at Ypsilanti, Mich. L. C. McLouth is Pres. Noted Sept. 2.

The John Larsen Co., Detroit, Mich., has awarded the contract for the construction of a two-story factory on Monroe Ave. J. H. Gustave Steffens is Arch.

Holmberg & Olsen, Chicago, Ill., will build a garage at 2307 Crawford Ave., to cost $5,000. W. Burfiend is Arch.

The Continental Bolt & Iron Co., 2219 West 43rd St., Chicago, Ill., will build a one-story addition to its plant to cost $6,000. J. N. Wettenstrom is Arch.

The Francis & Nigrin Foundry Co., Fillmore and Rockwell St., Chicago, Ill., plans the construction of a two-story, brick addition to its plant to cost $5,000. W. Tomlinson is Arch.